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DIVISION 03 - CONCRETE

SECTION 03101

FORMWORK FOR CONCRETE

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SECTION 03101

FORMWORK FOR CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 347R	(1994) Guide to Formwork for Concrete

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31	(1994) Making and Curing Concrete Test Specimens in the Field
ASTM C 39	(1994) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 1077	(1995a) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

DEPARTMENT OF COMMERCE (DOC)

DOC PS 1	(1983) Construction and Industrial Plywood

1.2 DESIGN REQUIREMENTS

The design, engineering, and construction of the formwork shall be the responsibility of the Contractor. The formwork shall be designed for leads, lateral pressure, and allowable stresses in accordance with Chapter 1 of ACI Standard 347. Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete and shall have sufficient rigidity to maintain specified tolerances. However, for surfaces with an ACI Class A surface designation, the allowable deflection for facing material between studs, for studs between walers and walers between bracing shall be limited to 0.0025 times the span. The formwork shall be designed as a complete system with consideration given to the effects of cementitious materials and mixture additives such as fly ash, cement type, plasticizers, accelerators, retarders, air entrainment, and others. The adequacy of formwork design and construction shall be monitored prior to and during concrete placement as part of the Contractor’s approved Quality Control Plan.

1.3 SUBMITTALS

Government approval is required for all submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01300 SUBMITTAL PROCEDURES:

SD-01 Data

Materials; FIO.

Manufacturer's literature shall be submitted for plywood, concrete form hard board, form accessories, prefabricated forms, form coating.

SD-04 Drawings

Shop Drawings; FIO.

Drawings and design computations for all formwork required shall be submitted at least 30 days either before fabrication on site or before delivery of prefabricated forms.

SD-09 Reports

Inspection; FIO.

The Contractor shall submit field inspection reports for concrete forms and embedded items.

1.4 SHOP DRAWINGS

The shop drawings and data submitted shall include the type, size, quantity, and strength of all materials of which the forms are made, the plan for jointing of facing panels, details affecting the appearance, and the assumed design values and loading conditions.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Forms and Form Liners

Forms and form liners shall be fabricated with facing materials that will produce a finish meeting the specified construction tolerance requirements and the following surface classifications as defined in ACI 347R, and as adjusted in Section 03301 CAST-IN-PLACE STRUCTURAL CONCRETE.

2.1.1.1 Class "A" Finish

This class of finish shall apply to all concrete surfaces exposed to flowing water during the life of the structure. The form facing material shall be composed of new, well-matched tongue-and-groove lumber or new plywood panels conforming to DOC PS 1, Grade B-B concrete form, Class I.

2.1.1.2 Class "B" Finish

This class of finish shall apply to all surfaces except those specified to receive Class A or Class D. The form facing material shall be composed of tongue-and-groove or shiplap lumber, plywood conforming to DOC PS 1, Grade B-B concrete form, tempered concrete form hard board or steel. Steel lining on wood sheathing will not be permitted.

2.1.1.3 Class "D" Finish

This class of finish shall apply to concrete faces against which earthfill will be placed. The form facing may be of wood or steel.

2.1.2 Form Coating

Form coating shall be commercial formulation that will not bond with, stain, cause deterioration, or any other damage to concrete surfaces. The coating shall not impair subsequent treatment of concrete surfaces depending upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds. If special form liners are to be used, the Contractor shall follow the recommendation of the form coating manufacturer.

2.2 ACCESSORIES

Ties and other similar form accessories to be partially or wholly embedded in the concrete shall be of a commercially manufactured type. After the ends or end fasteners have been removed, the embedded portion of metal ties shall terminate not less than 50 mm from any concrete surface either exposed to view or exposed to water. Plastic snap ties may be used in locations where the surface will not be exposed to view. Form ties shall be constructed so that the ends or end fasteners can be removed without spalling the concrete.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Form Construction

Forms shall be constructed true to the structural design and required alignment. The form surface and joints shall be mortar tight and supported to achieve safe performance during construction, concrete placement, and form removal. The Contractor shall continuously monitor the alignment and stability of the forms during all phases to assure the finished product will meet the required surface class or classes specified in paragraph FORMS AND FORM LINERS and tolerances specified in paragraph DESIGN REQUIREMENTS. Failure of any supporting surface either due to surface texture, deflection or form collapse shall be the responsibility of the Contractor as will the replacement or correction of unsatisfactory surfaces. When forms for continuous surfaces are placed in successive units, care shall be taken to fit the forms over the completed surface to obtain accurate alignment of the surface and to prevent leakage of mortar. Forms shall not be re-used if there is any evidence of defects which would impair the quality of the resulting concrete surface. All surfaces of used forms shall be cleaned of mortar and any other foreign material before reuse.

3.1.2 Chamfering

All exposed joints, edges and external corners shall be chamfered by molding placed in the forms unless the drawings specifically state that chamfering is to be omitted or as otherwise specified. Chamfered joints shall not be permitted where earth or rockfill is placed in contact with concrete surfaces. Chamfered joints shall be terminated 300 mm outside the limit of the earth or rockfill so that the end of the chamfers will be clearly visible.

3.1.3 Coating

Forms for exposed or painted surfaces shall be coated with form oil or a form-release agent before the form or reinforcement is placed in final

position. The coating shall be used as recommended in the manufacturer's instructions. Forms for unexposed surfaces may be wet with water in lieu of coating immediately before placing concrete, except that, in cold weather when freezing temperatures are anticipated, coating shall be mandatory. Surplus coating on form surfaces and coating on reinforcing steel and construction joints shall be removed before placing concrete.

3.2 FORM REMOVAL

Forms shall not be removed without approval. The minimal time required for concrete to reach a strength adequate for removal of formwork without risking the safety of workers or the quality of the concrete depends on a number of factors including, but not limited to, ambient temperature, concrete lift heights, type and amount of concrete admixture, and type and amount of cementitious material in the concrete. It is the responsibility of the Contractor to consider all applicable factors and leave the forms in place until it is safe to remove them. In any case forms shall not be removed unless the minimum strength requirements below are met, except as otherwise directed or specifically authorized. When conditions are such as to justify the requirement, forms will be required to remain in place for a longer period. All removal shall be accomplished in a manner which will prevent damage to the concrete and ensure the complete safety of the structure. Where forms support more than one element, the forms shall not be removed until the form removal criteria are met by all supported elements. Form removal shall be scheduled so that all necessary repairs can be performed as specified in Section 03301 CAST-IN-PLACE STRUCTURAL CONCRETE, paragraph FORMED SURFACES. Evidence that concrete has gained sufficient strength to permit removal of forms shall be determined by tests on control cylinders. All control cylinders shall be stored in the structure or as near the structure as possible so they receive the same curing conditions and protection methods as given those portions of the structure they represent. Control cylinders shall be removed from the molds at an age of no more than 24 hours. All control cylinders shall be prepared and tested in accordance with ASTM C 31 and ASTM C 39 at the expense of the Contractor by an independent laboratory that complies with ASTM C 1077 and shall be tested within 4 hours after removal from the site.

3.2.1 Formwork Not Supporting Weight of Concrete

Formwork for walls, columns, sides of beams, gravity structures, and other vertical type formwork not supporting the weight of concrete shall not be removed in less than 24 hours after concrete placement is completed.

3.2.2 Formwork Supporting Weight of Concrete

Formwork supporting weight of concrete and shoring shall not be removed until structural members have acquired sufficient strength to safely support their own weight and any construction or other superimposed loads to which the supported concrete may be subjected. As a minimum, forms shall be left in place until control concrete test cylinders indicate evidence the concrete has attained at least 70 percent of the compressive strength required for the structure in accordance with the quality and location requirements of Section 03301 CAST-IN-PLACE STRUCTURAL CONCRETE, paragraph REQUIRED AVERAGE COMPRESSIVE STRENGTH.

3.3 INSPECTION

Forms and embedded items shall be inspected in sufficient time prior to each concrete placement by the Contractor in order to certify to the

Contracting Officer that they are ready to receive concrete. The results of each inspection shall be reported in writing.

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DIVISION 03 - CONCRETE

SECTION 03150

EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN CONCRETE

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SECTION 03150

EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 1751	(1983; R 1991) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(1984; R 1992) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 2628	(1991) Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D 2835	(1989) Lubricant for Installation of Preformed Compression Seals in Concrete Pavements

FEDERAL SPECIFICATIONS (FS)

FS TT-S-00227	(Rev E; Am 3) Sealing Compound: Elastomeric Type, Multi-Component (for Caulking, Sealing, and Glazing in Buildings and Other Structures)

1.2 SUBMITTALS

Government approval is required for all submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01300 SUBMITTAL PROCEDURES:

SD-09 Reports

Premolded Expansion Joint Filler Strips; GA. Compression Seals and Lubricant; GA. Field Molded Sealants and Primer; GA.

Premolded expansion joint filler strips, compression seals and lubricant, field molded sealants and primer shall be accepted on the basis of the manufacturer’s certified test reports that materials meet the requirements of the specification under which they are furnished. No materials shall be used until notice of acceptance has been given by the Contracting Officer. Test reports of more than 6 months old shall be rejected and the materials shall be retested in conformance with paragraph TESTS, INSPECTIONS, AND VERIFICATIONS.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Premolded Expansion Joint Filler Strips

Premolded expansion joint filler strips shall conform to ASTM D 1751 or ASTM D 1752, Type I, or resin impregnated fiberboard conforming to the physical requirements of ASTM D 1752.

2.1.2 Joint Seals and Sealants

2.1.2.1 Field Molded Sealants and Primer

Field molded sealants shall conform to FS TT-S-00227, Type II for vertical joints and Type I for horizontal joints, Class A. Bond breaker material shall be polyethylene tape, coated paper, metal foil or similar type materials. The back-up material shall be compressible, nonshrink, nonreactive with sealant, and nonabsorptive material type such as extruded butyl or polychloroprene foam rubber.

2.1.2.2 Compression Seals and Lubricant

Compression seals shall conform to ASTM D 2628; lubricant for installation shall conform to ASTM D 2835.

2.2 TESTS INSPECTIONS, AND VERIFICATION

2.2.1 Materials Tests

2.2.1.1 Field-Molded Sealants

Samples of sealant and primer, when use of primer is recommended by the manufacturer, as required in paragraph FIELD MOLDED SEALANT AND PRIMER, shall be tested by and at the expense of the Contractor for compliance with FS TT-S-00227. If the sample fails to meet specification requirements, new samples shall be tested and the cost of retesting will be borne by the Contractor.

PART 3 EXECUTION

3.1 INSTALLATION

Joint locations and details, including materials and methods of installation of joint fillers shall be as specified, as shown, and as directed. In no case shall any fixed metal be continuous through an expansion or contraction joint.

3.1.1 Expansion Joints

Premolded filler strips shall have oiled wood strips secured to the top thereof and shall be accurately positioned and secured against displacement to clean, smooth concrete surfaces. The wood strips shall be slightly tapered, dressed and of the size required to install filler strips at the desired level below the finished concrete surface and to form the groove for the joint sealant or seals to the size shown. Material used to secure premolded fillers and wood strips to concrete shall not harm the concrete and shall be compatible with the joint sealant or seals. The wood strips

shall not be removed until after the concrete curing period. The groove shall be thoroughly cleaned of all laitance, curing compound, foreign materials, protrusions of hardened concrete and any dust which shall be blown out of the groove with oil-free compressed air.

3.1.1.1 Joints With Field-Molded Sealant

Joints shall not be sealed when the sealant, air or concrete temperature is less than 4 degrees C. Bond breaker and back-up material shall be installed where required. Joints shall be primed and filled flush with joint sealant in accordance with the manufacturer's recommendations.

3.1.1.2 Joints With Preformed Compression Seals

The joint seals shall be installed with equipment which shall be capable of installing joint seals to the prescribed depth without cutting, nicking, twisting, or otherwise distorting or damaging the seal and with no more than five percent stretching of the seal. The sides of the joint and, if necessary, the sides of the compression seal shall be covered with a coating of lubricant, and the seal shall be installed to the depth indicated with joint installation equipment. Butt joints shall be coated with liberal applications of lubricant.

3.1.2 Contraction Joints

Joints requiring a bond breaker shall be coated with curing compound or with bituminous paint.

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DIVISION 03 - CONCRETE

SECTION 03210

STEEL BARS FOR CONCRETE REINFORCEMENT

-- End of Section Table of Contents --

SECTION 03210

STEEL BARS FOR CONCRETE REINFORCEMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 315	(1980; R 1986) ACI Detailing Manual: Section Details and Detailing of Concrete Reinforcement
ACI 318M/318RM	(1995) Building Code Requirements for Reinforced Concrete (Metric)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 615/A 615M	(1993) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 706/A 706M	(1993a) Low-Alloy Steel Deformed Bars for Concrete Reinforcement

1.2 SUBMITTALS

Government approval is required for all submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01300 SUBMITTAL PROCEDURES:

SD-04 Drawings

Fabrication and Placement; GA.

The Contractor shall submit shop drawings which include: reinforcement steel placement drawings; reinforcement steel schedules showing quantity, size, shape, dimensions, weight per meter, total weights and bending details; and details of bar supports showing types, sizes, spacing and sequence.

SD-09 Reports

Materials; GA. Tests, Inspections, and Verifications; GA.

Certified tests reports of reinforcement steel showing that the steel complies with the applicable specifications shall be furnished for each steel shipment and identified with specific lots prior to placement.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Steel Bars

Steel bars shall comply with the requirements of ASTM A 615/A 615M or ASTM A 706/A 706M, deformed, of the grades, sizes and lengths shown.

2.1.2 Accessories

2.1.2.1 Bar Supports

Bar supports shall comply with the requirements of ACI 315. Supports for bars in concrete with formed surfaces exposed to view or to be painted shall be plastic-coated wire, stainless steel or precast concrete supports. Precast concrete supports shall be wedged-shaped, not larger than 90 by 90 mm, of thickness equal to that indicated for concrete cover and have an embedded hooked tie-wire for anchorage.

2.1.2.2 Wire Ties

Wire ties shall be 16 gage or heavier black annealed wire.

PART 3 EXECUTION

3.1 FABRICATION AND PLACEMENT

Reinforcement steel and accessories shall be fabricated and placed as specified and shown on approved shop drawings. Fabrication and placement details of steel and accessories not specified or shown shall be in accordance with ACI 318M/318RM or as directed. Steel shall be fabricated to shapes and dimensions shown, placed where indicated within specified tolerances and adequately supported during concrete placement. At the time of concrete placement all steel shall be free from loose, flaky rust, scale (except tight mill scale), mud, oil, grease or any other coating that might reduce the bond with the concrete.

3.1.1 Hooks and Bends

Steel bars shall be mill or field-bent. All steel shall be bent cold unless authorized. No steel bars shall be bent after being partially embedded in concrete unless indicated or authorized.

3.1.2 Placing Tolerances

3.1.2.1 Spacing

The spacing between adjacent bars and the distance between layers of bars may not vary from the indicated position by more than one bar diameter nor more than 25 mm.

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DIVISION 03 - CONCRETE

SECTION 03301

CAST-IN-PLACE STRUCTURAL CONCRETE

-- End of Section Table of Contents --

SECTION 03301

CAST-IN-PLACE STRUCTURAL CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 117/117R	(1990; Errata) Standard Tolerances for Concrete Construction and Materials
ACI 211.1	(1991) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 214	(1977; R 1989) Evaluation of Strength Test Results of Concrete
ACI 305R	(1991) Hot Weather Concreting
ACI 318M/318RM	(1995) Building Code Requirements for Reinforced Concrete (Metric)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31	(1994) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(1993) Concrete Aggregates
ASTM C 39	(1994) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 42	(1994) Obtaining and Testing Drilled Cores and Sawed Beam of Concrete
ASTM C 94	(1997) Ready-Mixed Concrete
ASTM C 136	(1995a) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 143	(1990a) Slump of Hydraulic Cement Concrete
ASTM C 150	(1995) Portland Cement
ASTM C 171	(1992) Sheet Materials for Curing Concrete
ASTM C 172	(1990a) Sampling Freshly Mixed Concrete
ASTM C 192	(1990a) Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	(1991b) Air Content of Freshly Mixed

	Concrete by the Pressure Method
ASTM C 260	(1994) Air-Entraining Admixtures for Concrete
ASTM C 309	(1994) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 494	(1992) Chemical Admixtures for Concrete
ASTM C 566	(1989) Total Moisture Content of Aggregate by Drying
ASTM C 597	(1983; R 1991) Pulse Velocity Through Concrete
ASTM C 618	(1994a) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C 803	(1990) Penetration Resistance of Hardened Concrete
ASTM C 805	(1994) Rebound Number of Hardened Concrete
ASTM C 881	(1990) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 1059	(1991) Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C 1064	(1986; R 1993) Temperature of Freshly Mixed Portland Cement Concrete
ASTM C 1077	(1995a) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1107	1991a) Package Dry, Hydraulic-Cement Grout (Non-shrink)(
ASTM D 75	(1987; R 1992) Sampling Aggregates

CORPS OF ENGINEERS (COE)

COE CRD-C 94	(1995) Specifications for Surface Retarders
COE CRD-C 100	(1975) Method of Sampling Concrete Aggregate and Aggregate Sources, and Selection of Material for Testing
COE CRD-C 104	(1980) Method of Calculation of the Fineness Modulus of Aggregate
COE CRD-C 112	(1969) Method of Test for surface Moisture in aggregate by Water Displacement
COE CRD-C 143	(1962) Meters for Automatic Indication of Moisture in Fine Aggregate

COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(1994) NIST Handbook 44: Specifications, Tolerances, and other Technical Requirements for Weighing and Measuring Devices

NATIONAL READY-MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(1990) Concrete Plant Standards

1.2 SUBMITTALS

Government approval is required for all submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01300 SUBMITTAL PROCEDURES.

SD-01 Data

Concrete Mixture Proportioning; FIO.

Concrete mixture proportions shall be determined by the Contractor, in accordance with the requirements in paragraph CONCRETE MIXTURE PROPORTIONING, and submitted for review. The concrete mixture quantities of all ingredients per cubic meter and nominal maximum coarse aggregate size that will be used in the manufacture of each quality of concrete shall be stated. Proportions shall indicate the mass of cement, pozzolan when used, and water; the mass of aggregates in a saturated surface-dry condition; and the quantities of admixtures. The submission shall be accompanied by test reports from a laboratory complying with ASTM C 1077 which show that proportions thus selected will produce concrete of the qualities indicated. No substitution shall be made in the source or type of materials used in the work without additional tests to show that the quality of the new materials and concrete are satisfactory.

Concrete Mixers; FIO.

The Contractor shall submit concrete mixer data which includes the make, type, and capacity of concrete mixers proposed for mixing concrete in conformance with the paragraphs CAPACITY and CONCRETE MIXERS.

Conveying Equipment and Methods; FIO.

The conveying equipment and methods for transporting, handling, and depositing the concrete shall be submitted for review by the Contracting Officer for conformance with paragraphs CAPACITY and CONVEYING EQUIPMENT.

Placing Equipment and Methods; FIO.

All placing equipment and methods shall be submitted for review by the Contracting Officer for conformance with paragraph CAPACITY.

SD-08 Statements

Testing Technicians; FIO. Concrete Construction Inspector; FIO.

The Contractor shall submit statements that the concrete testing technicians and the concrete inspectors meet the requirements of paragraph TESTS AND INSPECTIONS.

Construction Joint Treatment; GA.

The method and equipment proposed for joint cleanup and waste disposal shall be submitted for review and approval for conformance with paragraph CONSTRUCTION JOINT TREATMENT.

Curing and Protection; GA.

The curing medium and methods to be used shall be submitted for review and approval for conformance with paragraph CURING AND PROTECTION.

Cold-Weather Placing; GA.

If concrete is to be placed under cold-weather conditions, the proposed materials, methods, and protection meeting the requirements of paragraph COLD-WEATHER PLACING shall be submitted for approval.

Hot-Weather Placing; GA.

If concrete is to be placed under hot-weather conditions, the proposed materials and methods, meeting the requirements of paragraph HOT-WEATHER PLACING and paragraph FINISHING, shall be submitted for review and approval.

SD-09 Reports

Aggregate Quality; GA.

Aggregate quality tests shall be submitted at least 30 days prior to start of concrete placement, in accordance with the applicable COE CRD-C or ASTM test methods.

Uniformity of Concrete Mixing; FIO.

The results of the initial mixer uniformity tests as required in paragraph MIXER UNIFORMITY shall be submitted at least 5 days prior to the initiation of placing.

Tests and Inspections; FIO.

Test results and inspection reports shall be submitted daily and weekly as required in paragraph REPORTS.

SD-13 Certificates

Cementitious Materials; FIO.

Cementitious Materials, including Cement and Pozzolan, will be accepted on the basis of the manufacturer’s certification of compliance, accompanied by mill test reports that materials meet the requirements of the specification under which they are furnished. Certification and mill test reports shall

be from samples taken from the particular lot furnished. No cementitious materials shall be used until notice of acceptance has been given by the Contracting Officer. Cementitious materials will be subject to check testing from samples obtained at the source, at transfer points, or at the project site, as scheduled by the Contracting Officer, and such sampling will be by or under the supervision of the Government at its expense. Material not meeting specifications shall be promptly removed from the site of work.

Other Chemical Admixtures; FIO.

Other Chemical Admixtures shall be certified for compliance with all specification requirements.

Membrane-Forming Curing Compound; FIO.

Membrane-Forming Curing Compound shall be certified for compliance with all specification requirements.

Epoxy Resin; FIO. Latex Bonding Compound; FIO.

Epoxy Resin and Latex Bonding Compound shall be certified for compliance with all specification requirements.

Non-shrink Grout; FIO.

Descriptive literature of the non-shrink grout proposed for use shall be furnished together with a certificate from the manufacturer stating that it is suitable for the application for which it is being considered.

1.3 GOVERNMENT TESTING AND SAMPLING

The Government will sample and test aggregates and concrete to determine compliance with the specifications. The Contractor shall provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with ASTM D 75. Concrete will be sampled in accordance with ASTM C 172.

1.3.1 Preconstruction Sampling and Testing

1.3.1.1 Aggregates

The aggregate sources listed in paragraph CONCRETE AGGREGATE SOURCES have been tested and at the time testing was performed were capable of producing materials of a quality required for this project. The Contractor may furnish materials from a listed source or from a source not listed. Samples from any source of coarse aggregate and any source of fine aggregate selected by the Contractor, consisting of not less than 70 kg of each size coarse aggregate and 35 kg of fine aggregate taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100 shall be delivered to a local materials testing laboratory selected by the Government within 15 days after notice to proceed. Sampling and shipment of samples shall be at the Contractor’s expense. Sixty (60) days will be required to complete the evaluation of the aggregates. Testing will be performed by and at the expense of the Government in accordance with the applicable COE CRD-C or ASTM test methods. The cost of testing one source for each size of aggregate will be borne by the Government. If the Contractor selects more than one source for each aggregate size or selects

a substitute source for any size aggregate after the original source was tested, the cost of that additional testing will be borne by the Contractor. Tests to which aggregate may be subjected are specific gravity, absorption, soft particles, L.A. abrasion, and any test necessary to demonstrate that the aggregate is of a quality that is at least equivalent to those sources listed herein and meeting the requirements of ASTM C33. The Government's test data and other information on aggregate quality of those sources listed herein are included in the Design Memorandum and are available for review in the district office. Testing of aggregates by the Government does not relieve the Contractor of the requirements outlined in paragraph TESTS AND INSPECTIONS.

1.3.1.2 Cementitious Materials, Admixtures, and Curing Compound

At least 60 days in advance of concrete placement, the Contractor shall notify the Contracting Officer of the sources for cementitious materials, admixtures, and curing compound, along with sampling location, brand name, type, and quantity to be used in the manufacture and/or curing of the concrete.

1.3.2 Construction Testing by the Government

Sampling and testing will be performed by and at the expense of the Government except as otherwise specified. No material shall be used until notice has been given by the Contracting Officer that test results are satisfactory.

1.3.2.1 Chemical Admixtures Storage

Chemical admixtures that have been in storage at the project site for longer than 6 months or that have been subjected to freezing shall be retested at the expense of the Contractor when directed by the Contracting Officer and shall be rejected if test results are not satisfactory. Chemical admixtures will be accepted based on compliance with the requirements of paragraph CHEMICAL ADMIXTURES.

1.3.2.2 Cement and Pozzolan

If cement or pozzolan is to be obtained from more than one source, the initial notification shall state the estimated amount to be obtained from each source and the proposed schedule of shipments.

1.3.2.3 Concrete Strength

Compressive strength test specimens will be made by the Government and cured in accordance with ASTM C 31 and tested in accordance with ASTM C 39. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'c and no individual test result falls below the specified strength f'c by more than 3.5 MPa. A "test" is defined as the average of two companion cylinders, or if only one cylinder is tested, the results of the single cylinder test. Additional analysis or testing, including nondestructive testing, taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the structure is considered potentially deficient.

a. Investigation of Low-Strength Test Results - When any strength test of standard-cured test cylinders falls below the specified strength requirement by more than 3.5 MPa or if tests of field-cured cylinders

indicate deficiencies in protection and curing, steps shall be taken to assure that the load-carrying capacity of the structure is not jeopardized. Nondestructive testing in accordance with ASTM C 597, ASTM C 803, or ASTM C 805 may be permitted by the Contracting Officer to estimate the relative strengths at various locations in the structure as an aid in evaluating concrete strength in place or for selecting areas to be cored. Such tests shall not be used as a basis for acceptance or rejection.

b. Testing of Cores - When the strength of concrete in place is considered potentially deficient, cores shall be obtained and tested in accordance with ASTM C 42. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the performance of the structure. Concrete in the area represented by the core testing will be considered adequate if the average strength of the cores is equal to at least 85 percent of the specified strength requirement and if no single core is less than 75 percent of the specified strength requirement.

c. Load Tests - If the core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be directed by the Contracting Officer in accordance with the requirements of ACI 318M/318RM. Concrete work evaluated by structural analysis or by results of a load test shall be corrected in a manner satisfactory to the Contacting Officer. All investigations, testing, load tests, and correction of deficiencies will be performed and approved by the Contracting Officer at the expense of the Contractor, except that if all concrete is in compliance with the plans and specifications, the cost of investigations, testing, and load tests will be at the expense of the Government.

1.4 DESIGN REQUIREMENTS

1.4.1 Concrete Strength

Specified compressive strength f’c shall be as follows:

COMPRESSIVE STRENGTH (MPa)	STRUCTURE OR PORTION OF STRUCTURE
30 @ 28 days	Box culvert and similar types of structure
25 @ 28 days	Open Channel and general construction

1.4.2 Maximum Water-Cement (W/C) Ratio

Maximum W/C shall be as follows:

WATER-CEMENT RATIO, BY MASS	STRUCTURE OR PORTION OF STRUCTURE
0.45	All elements subjected to flow of water

These W/C’s may cause higher strengths than that required by paragraph CONCRETE STRENGTH.

1.5 CONSTRUCTION TOLERANCES

1.5.1 General

The definitions of the terms used in the following tables shall be as defined in ACI 117/117R. Level and grade tolerance measurements of slabs shall be made as soon as possible after finishing. When forms or shoring are used, the measurements shall be made prior to removal. Tolerances are not cumulative. The most restrictive tolerance controls. Tolerances shall not extend the structure beyond legal boundaries. Except as specified otherwise, plus tolerance increases the amount or dimension to which it applies, or raises a level alignment, and minus tolerance decreases the amount or dimension to which it applied, or lowers a level alignment. A tolerance without sign means plus or minus. Where only one signed tolerance is specified, there is no limit in the other direction.

ALL STRUCTURES EXPOSED TO FLOW

(1)	Departure from established alignment or from established grade	.....	13 mm
(2)	Variation in thickness, at any point	.....	minus 2-1/2 percent or 6 mm, whichever is greater
		.....	plus 5 percent or 13 mm, whichever is greater
(3)	Variation from inside dimensions	.....	1/2 of 1 percent
(4)	Departure from established alignment	.....	50 mm on tangents
		.....	100 mm on curves
(5)	Departure from established profile grade	.....	25 mm
(6)	Reduction in thickness in lining	.....	10 percent of specified thickness: provided that average thickness is maintained as determined by daily batch volumes
(7)	Variation from specified width of section at any height	.....	1/4 of 1 percent plus 25 mm
(8)	Variations in surfaces	.....	Invert 3 mm in 1000 mm Side slopes 4 mm in 1000 mm

(9) Abrupt Variation

The offset between concrete surfaces for the following classes of

ALL STRUCTURES EXPOSED TO FLOW
surface:

Class A	.....	3 mm
Class B	.....	6 mm
Class D	.....	25 mm

(10) Gradual Variation

Surface finish tolerances as measured by placing a freestanding (unleveled), 1.5 m straightedge for plane surface or curved template for curved surface anywhere on the surface and allowing it to rest upon two high spots within 72 hr after concrete placement. The gap at any point between the straightedge or template and the surface shall not exceed:

Class A	.....	3 mm
Class B	.....	6 mm
Class D	.....	25 mm

1.5.2 Appearance

Permanently exposed surfaces shall be cleaned, if stained or otherwise discolored, by a method that does not harm the concrete and that is approved by the Contracting Officer.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

Cementitious materials shall be portland cement, portland-pozzolan cement, or portland cement in combination with pozzolan and shall conform to appropriate specifications listed below.

2.1.1.1 Portland Cement

ASTM C 150, Type V, low alkali.

2.1.1.2 High-Early-Strength Portland Cement

ASTM C 150, Type III, with C3A limited to 8 percent, low alkali. Type III cement shall be used only in isolated instances and only when specifically approved in writing.

2.1.1.3 Pozzolan

Pozzolan shall conform to ASTM C 618, Class F, with the loss on ignition limited to 6 percent and the optional requirements for multiple factor, drying shrinkage, and uniformity from Table 2A.

2.1.2 Aggregates

2.1.2.1 General

Concrete aggregates may be furnished from any source capable of meeting the quality requirements as stated herein below. Fine and coarse aggregates shall conform to the grading requirements of ASTM C 33. The nominal

maximum size shall be as listed in paragraph NOMINAL MAXIMUM-SIZE COARSE AGGREGATE. Where the use of highway department gradations are permitted, proposed gradations shall be submitted for approval.

2.1.2.2 Concrete Aggregate Sources

a. List of Sources - The concrete aggregates sources may be selected from the following existing commercial sources:

Nevada Ready Mix	Lone Mountain Pit
WMK Materials	Buffalo Road Pit

b. Selection of Source - After the award of the contract, the Contractor shall designate in writing only one source or combination of sources from which he proposes to furnish aggregates. If the Contractor proposes to furnish aggregates from a source or from sources not listed above, he may designate only a single source or single combination of sources for aggregates. Regardless of the source, selected samples for acceptance testing shall be provided as required by paragraph GOVERNMENT TESTING AND SAMPLING. If a source for coarse or fine aggregates so designated by the Contractor does not meet the quality requirements of ASTM C 33 and other applicable ASTM tests, the Contractor may not submit for approval other non-listed sources but shall furnish the coarse or fine aggregate, as the case may be, from sources listed above at no additional cost to the Government.

2.1.3 Chemical Admixtures

Chemical admixtures to be used, when required or permitted, shall conform to the appropriate specification listed.

2.1.3.1 Air-Entraining Admixture

The air-entraining admixture shall conform to ASTM C 260 and shall consistently cause the concrete to have an air content in the specified ranges under field conditions.

2.1.3.2 Accelerating Admixture

Accelerators shall meet the requirements of ASTM C 494, Type C or E, except that calcium chloride or admixtures containing calcium chloride shall not be used.

2.1.3.3 Water-Reducing or Retarding Admixture

ASTM C 494, Type A, B, or D, except that the 6-month and 1-year compressive strength test results are waived.

2.1.4 Curing Materials

2.1.4.1 Impervious-Sheet Curing Materials

Impervious-sheet curing materials shall conform to ASTM C 171, type optional, except polyethylene film shall not be used.

2.1.4.2 Membrane-Forming Curing Compound

The membrane-forming curing compound shall conform to ASTM C 309, Type 2.

2.1.5 Water

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that nonpotable water may be used if it meets the requirements of COE CRD-C 400.

2.1.6 Latex Bonding Compound

Latex bonding compound agents for bonding fresh to hardened concrete shall conform to ASTM C 1059.

2.1.7 Epoxy Resin

Epoxy resins for use in repairs shall conform to ASTM C 881, Type III, Grade I or II.

2.1.8 Non-shrink Grout

Non-shrink grout shall conform to ASTM C 1107 and shall be a commercial formulation suitable for the application proposed.

2.2 CONCRETE MIXTURE PROPORTIONING

2.2.1 Quality of Mixture

For each portion of the structure, mixture proportions shall be selected so that the strength and W/C requirements listed in paragraph DESIGN REQUIREMENTS are met.

2.2.2 Nominal Maximum-Size Coarse Aggregate

Nominal maximum-size coarse aggregate shall be 37.5 mm except 19.0 mm nominal maximum-size coarse aggregate shall be used when any of the following conditions exist: the narrowest dimension between sides of forms is less than 190 mm, the depth of the slab is less than 100 mm, or the minimum clear spacing between reinforcing is less than 55 mm.

2.2.3 Air Content

Air content as delivered to the forms and as determined by ASTM C 231 shall be between 4 and 7 percent except that when the nominal maximum-size coarse aggregate is 19.0 mm, it shall be between 4-1/2 and 7-1/2 percent.

2.2.4 Slump

The slump shall be determined in accordance with ASTM C 143 and shall be within the range of 25 mm to 100 mm. Where placement by pump is approved, the slump shall not exceed 150 mm.

2.2.5 Concrete Proportioning

Trial batches and testing requirements for various qualities of concrete specified shall be the responsibility of the Contractor. Samples of aggregates shall be obtained in accordance with the requirements of ASTM D 75. Samples of materials other than aggregate shall be representative of those proposed for the project and shall be accompanied by the manufacturer’s test reports indicating compliance with applicable specified requirements. Trial mixtures having proportions, consistencies, and air content suitable for the work shall be made based on methodology described

in ACI 211.1, using at least three different water-cement ratios, which will produce a range of strength encompassing those required for the work. The maximum water-cement ratios required in paragraph MAXIMUM WATER-CEMENT RATIO will be converted to a weight ratio of water to cement plus pozzolan by mass as described in ACI 211.1. Trial mixtures shall be proportioned for maximum permitted slump and air content with due consideration to the approved conveying and placement method. The temperature of concrete in each trial batch shall be reported. For each water-cement ratio, at least three test cylinders for each test age shall be made and cured in accordance with ASTM C 192. They shall be tested at 7 days and at the design age specified in paragraph DESIGN REQUIREMENTS in accordance with ASTM C 39. From these test results, a curve will be plotted showing the relationship between water-cement ratio and strength.

2.2.6 Required Average Compressive Strength

In meeting the water-cement ratio and strength requirements specified in paragraph CONCRETE STRENGTH, the selected mixture proportion shall produce a required average compressive strength f'cr exceeding the specified strength f'c by the amount indicated below.

2.2.6.1 Average Compressive Strength from Test Records

Where a concrete production facility has test records, a standard deviation shall be established in accordance with the applicable provisions of ACI 214. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected, shall represent concrete produced to meet a specified strength or strengths (f'c) within 6.89 MPa of that specified for proposed work, and shall consist of at least 30 consecutive tests. A strength test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days or at another test age designated for determination of f'c.

Required average compressive strength f'cr used as the basis for selection of concrete proportions shall be the larger of the equations that follow using the standard deviation as determined above:

$$f'cr = f'c + 1.34S$$
$$f'cr = f'c + 2.33S - 3.45$$

Where S = standard deviation

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation shall be established as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS*	MODIFICATION FACTOR FOR STANDARD DEVIATION Use tabulation in paragraph DETERMINING REQUIRED AVERAGE STRENGTH
less than 15	
15	1.16
20	1.08
25	1.03
30 or more	1.00

NUMBER OF TESTS*	MODIFICATION FACTOR FOR STANDARD DEVIATION Use tabulation in paragraph DETERMINING REQUIRED AVERAGE STRENGTH
less than 15	

*Interpolate for intermediate numbers of tests.

2.2.6.2 Average Compressive Strength without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required average strength fcr shall be determined as follows:

If the specified compressive strength f'c is 20.7 to 34.5 MPa,

$$f'cr = f'c + 8.27$$

PART 3 EXECUTION

3.1 EQUIPMENT

3.1.1 Capacity

The batching, mixing, conveying, and placing equipment shall have a capacity of at least 100 cubic meters per hour.

3.1.2 Batch Plant

Batching plant shall conform to the requirements of NRMCA CPMB 100 and as specified; however, rating plates attached to batch plant equipment are not required.

3.1.2.1 Batching Equipment

The batching controls shall be semiautomatic or automatic. The semiautomatic batching system shall be provided with interlocks such that the discharge device cannot be actuated until the indicated material is within the applicable tolerance. The batching system shall be equipped with an accurate recorder or recorders that meet the requirements of NRMCA CPMB 100. Separate bins or compartments shall be provided for each size group of aggregate, cement, and pozzolan. Aggregates shall be weighed either in separate weigh batchers with individual scales or cumulatively in one weigh batcher on one scale. Aggregate shall not be weighed in the same batcher with cement or pozzolan. If both cement and pozzolan are used, they may be batched cumulatively provided that the portland cement is batched first. If measured by mass, the mass of the water shall not be weighed cumulatively with another ingredient. Water batcher filling and discharging valves shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. An accurate mechanical device for measuring and dispensing each admixture shall be provided. Each dispenser shall be interlocked with the batching and discharging operation of the water so that each admixture is separately batched and discharged automatically in a manner to obtain uniform distribution throughout the batch in the specified mixing period. Admixtures shall not be combined prior to introduction in water. The plant shall be arranged so as to facilitate the inspection of all operations at all times. Suitable facilities shall be provided for obtaining representative samples of aggregates from each bin or compartment. All filling ports for cementitious materials bins or silos shall be clearly marked with a

permanent sign stating the contents.

3.1.2.2 Scales

The equipment for batching by mass shall conform to the applicable requirements of NIST HB 44, except that the accuracy shall be plus or minus 0.2 percent of scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring devices. Tests shall be made at the frequency required in paragraph TESTS AND INSPECTIONS, and in the presence of a government inspector.

3.1.2.3 Batching Tolerances

a. Weighing Tolerances

MATERIAL	PERCENT OF REQUIRED MASS
Cementitious materials	0 to plus 2
Aggregate	plus or minus 2
Water	plus or minus 1
Chemical admixture	0 to plus 6

b. Volumetric Tolerances - For volumetric batching equipment, the following tolerances shall apply to the required volume of material being batched:

Water: ..... Plus or minus 1 percent.
Chemical admixtures: ..... Zero to plus 6 percent.

3.1.2.4 Moisture Control

The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the masses of the materials being batched. An electric moisture meter complying with the provisions of COE CRD-C 143 shall be provided for measuring moisture in the fine aggregate. The sensing element shall be arranged so that the measurement is made near the batcher charging gate of the sand bin or in the sand batcher.

3.1.3 Concrete Mixers

The concrete mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired.

3.1.3.1 Stationary Mixers

Concrete plant mixers shall be tilting, nontilting, horizontal-shaft, vertical-shaft, or pugmill and shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. The mixing time and uniformity shall conform to all the requirements in ASTM C 94 applicable to central-mixed concrete.

3.1.3.2 Truck Mixers

Truck mixers, the mixing of concrete therein, and concrete uniformity shall conform to the requirements of ASTM C 94. A truck mixer may be used either for complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). Each truck shall be equipped with two counters from which it will be possible to determine the number of revolutions at mixing speed and the number of revolutions at agitating speed.

3.1.4 Conveying Equipment

The conveying equipment shall conform to the following requirements.

3.1.4.1 Buckets

The interior hopper slope shall be not less than 58 degrees from the horizontal, the minimum dimension of the clear gate opening shall be at least five times the nominal maximum-size aggregate, and the area of the gate opening shall not be less than 0.2 square meter. The maximum dimension of the gate opening shall not be greater than twice the minimum dimension. The bucket gates shall be essentially grout tight when closed and may be manually, pneumatically, or hydraulically operated except that buckets larger than 1.5 cubic meters shall not be manually operated. The design of the bucket shall provide means for positive regulation of the amount and rate of deposit of concrete in each dumping position.

3.1.4.2 Transfer Hoppers

Concrete may be charged into nonagitating hoppers for transfer to other conveying devices. Transfer hoppers shall be capable of receiving concrete directly from delivery vehicles and have conical-shaped discharge features. The transfer hopper shall be equipped with a hydraulically operated gate and with a means of external vibration to effect complete discharge. Concrete shall not be held in nonagitating transfer hoppers more than 30 minutes.

3.1.4.3 Trucks

Truck mixers operating at agitating speed or truck agitators used for transporting plant-mixed concrete shall conform to the requirements of ASTM C 94. Nonagitating equipment may be used for transporting plant-mixed concrete over a smooth road when the hauling time is less than 15 minutes. Bodies of nonagitating equipment shall be smooth, watertight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation, and equipped with gates that will permit positive control of the discharge of the concrete.

3.1.4.4 Chutes

When concrete can be placed directly from a truck mixer, agitator, or nonagitating equipment, the chutes attached to this equipment by the manufacturer may be used. A discharge deflector shall be used when required by the Contracting Officer. Separate chutes and other similar equipment will not be permitted for conveying concrete.

3.1.4.5 Belt Conveyors

Belt conveyors shall be designed and operated to assure a uniform flow of concrete from mixer to final place of deposit without segregation of ingredients or loss of mortar and shall be provided with positive means for preventing segregation of the concrete at the transfer points and the point of placing. Belt conveyors shall be constructed such that the idler spacing shall not exceed 900 mm. The belt speed shall be a minimum of 90 m per minute and a maximum of 230 m per minute. If concrete is to be placed through installed horizontal or sloping reinforcing bars, the conveyor shall discharge concrete into a pipe or elephant trunk that is long enough to extend through the reinforcing bars.

3.1.4.6 Concrete Pumps

Concrete may be conveyed by positive displacement pump when approved. The pumping equipment shall be piston or squeeze pressure. The pipeline shall be rigid steel pipe or heavy-duty flexible hose. The inside diameter of the pipe shall be at least three times the nominal maximum-size coarse aggregate in the concrete mixture to be pumped but not less than 100 mm. Aluminum pipe shall not be used. The maximum-size coarse aggregate shall not be reduced to accommodate the pumps. The distance to be pumped shall not exceed limits recommended by the pump manufacturer. The concrete shall be supplied to the concrete pump continuously. When pumping is completed, concrete remaining in the pipeline shall be ejected without contamination of concrete in place. After each operation, equipment shall be thoroughly cleaned, and flushing water shall be wasted outside of the forms.

3.1.5 Vibrators

Vibrators of the proper size, frequency, and amplitude shall be used for the type of work being performed in conformance with the following requirements:

APPLICATION	HEAD DIAMETER mm	FREQUENCY VPM	AMPLITUDE mm
General construction	50 to 88	8,000 to 12,000	0.6 to 1.2

The frequency and amplitude shall be determined in accordance with COE CRD-C 521.

3.2 PREPARATION FOR PLACING

3.2.1 Embedded Items

Before placement of concrete, care shall be taken to determine that all embedded items are firmly and securely fastened in place as indicated on the drawings, or required. Embedded items shall be free of oil and other foreign matter such as loose coatings or rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable materials to prevent the entry of concrete into voids. Welding, including tack welding, will not be permitted on embedded metals within 600 mm of the surface of the concrete.

3.2.2 Concrete on Earth Foundations

Earth surfaces upon which concrete is to be placed shall be clean, damp,

and free from debris, frost, ice, and standing or running water. Prior to placement of concrete, the earth foundation shall have been satisfactorily compacted in accordance with Section 02250 FILLS AND SUBGRADE PREPARATION. Additionally, the foundation shall be inspected by the Contractor prior to concrete placement in order certify that it is ready to receive concrete. The results of each inspection shall be submitted in writing.

3.2.3 Concrete on Rock Foundations

Rock surfaces upon which concrete is to be placed shall be clean, free from oil, standing or running water, ice, mud, drummy rock, coating, debris, and loose, semidetached, or unsound fragments. Joints in rock shall be cleaned to a satisfactory depth, as determined by the Contracting Officer, and to firm rock on the sides. Immediately before the concrete is placed, all rock surfaces shall be cleaned thoroughly by the use of air-water jets or sandblasting as described in paragraph CONSTRUCTION JOINT TREATMENT. All rock surfaces shall be kept continuously wet for at least 24 hours immediately prior to placing concrete thereon. All approximately horizontal surfaces shall be covered, immediately before the concrete is placed, with a layer of mortar proportioned similar to that in the concrete mixture. The mortar shall be covered with concrete before the time of initial setting of the mortar.

3.2.4 Construction Joint Treatment

Construction joint treatment shall conform to the following requirements.

3.2.4.1 Joint Preparation

Concrete surfaces to which additional concrete is to be bonded shall be prepared for receiving the next lift or adjacent concrete by cleaning with either air-water cutting, sandblasting, high-pressure water jet, or other approved method. Air-water cutting will not be permitted on formed surfaces or surfaces congested with reinforcing steel. Regardless of the method used, the resulting surfaces shall be free from all laitance and inferior concrete so that clean, well bonded coarse aggregate is exposed uniformly throughout the lift surface. The edges of the coarse aggregate shall not be undercut. The surface shall be washed clean again as the last operation prior to placing the next lift. There shall be no standing water on the surface upon which concrete is placed.

3.2.4.2 Air-Water Cutting

Air-water cutting of a construction joint shall be performed at the proper time and only on horizontal construction joints. The air pressure used in the jet shall be 620 to 760 kPa, and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. When approved by the Contracting Officer, a retarder complying with the requirements of COE CRD-C 94 may be applied to the surface of the lift to prolong the period of time during which air-water cutting is effective. Prior to receiving approval, the Contractor shall furnish samples of the material to be used and shall demonstrate the method to be used in applications. After cutting, the surface shall be washed and rinsed as long as there is any trace of cloudiness of the wash water. Where necessary to remove accumulated laitance, coatings, stains, debris, and other foreign material, high-pressure water jet or sandblasting will be required as the last operation before placing the next lift.

3.2.4.3 High-Pressure Water Jet

A stream of water under a pressure of not less than 20.7 MPa may be used for cleaning. Its use shall be delayed until the concrete is sufficiently hard so that only the surface skin or mortar is removed and there is no undercutting of coarse-aggregate particles. If the water jet is incapable of a satisfactory cleaning, the surface shall be cleaned by sandblasting.

3.2.4.4 Wet Sandblasting

This method may be used when the concrete has reached sufficient strength to prevent undercutting of the coarse aggregate particles. The surface of the concrete shall then be washed thoroughly to remove all loose materials.

3.2.4.5 Waste Disposal

The method used in disposing of waste water employed in cutting, washing, and rinsing of concrete surfaces shall be such that the waste water does not stain, discolor, or affect exposed surfaces of the structures, or damage the environment of the project area. The method of disposal shall be subject to approval.

3.3 PLACING

3.3.1 Placing Procedures

The surfaces of horizontal construction joints shall be kept continuously wet for the first 12 hours during the 24-hour period prior to placing concrete. Surfaces may be dampened immediately before placement if necessary. Concrete placement will not be permitted when, in the opinion of the Contracting Officer, weather conditions prevent proper placement and consolidation. Concrete shall be deposited as close as possible to its final position in the forms and, in so depositing, there shall be no vertical drop greater than 1.5 m except where suitable equipment is provided to prevent segregation and where specifically authorized. Depositing of the concrete shall be so regulated that it may be effectively consolidated in horizontal layers 600 mm or less in thickness with a minimum of lateral movement. The amount deposited in each location shall be that which can be readily and thoroughly consolidated. Sufficient placing capacity shall be provided so that concrete placement can be kept plastic and free of cold joints while concrete is being placed. Concrete shall be placed by methods that will prevent segregation or loss of ingredients. Any concrete transferred from one conveying device to another shall be passed through a hopper that is conical in shape. The concrete shall not be dropped vertically more than 1.5 m, except where a properly designed and sized elephant truck with rigid drop chute bottom section is provided to prevent segregation and where specifically authorized. In no case will concrete be discharged to free-fall through reinforcing bars.

3.3.2 Placement by Pump

When concrete is to be placed by pump, the nominal maximum-size coarse aggregate shall not be reduced to accommodate the pumps. The distance to be pumped shall not exceed limits recommended by the pump manufacturer. The concrete shall be supplied to the concrete pump continuously. When pumping is completed, concrete remaining in the pipeline shall be ejected without contamination of concrete in place. After each operation, equipment shall be thoroughly cleaned, and flushing water shall be wasted outside of the forms. Grout used to lubricate the pumping equipment at the beginning of the placement will not be incorporated into the placement.

3.3.3 Time Interval Between Mixing and Placing

Concrete shall be placed within 30 minutes after discharge into nonagitating equipment. When concrete is truck-mixed or when a truck mixer or agitator is used for transporting concrete mixed by a concrete plant mixer, the concrete shall be delivered to the site of the work, and discharge shall be completed within 1-1/2 hours after introduction of the cement to the aggregates. When the length of haul makes it impossible to deliver truck-mixed concrete within these time limits, batching of cement and a portion of the mixing water shall be delayed until the truck mixer is at or near the construction site.

3.3.4 Cold-Weather Placing

When concrete is likely to be subjected to freezing temperatures before the expiration of the curing period, it shall be placed in accordance with procedures previously submitted in accordance with paragraph SUBMITTALS. The ambient temperature of the space adjacent to the concrete placement and surfaces to receive concrete shall be above 0 degrees C. The placing temperature of the concrete having a minimum dimension less than 300 mm shall be between 12 and 24 degrees C when measured in accordance with ASTM C 1064. The placing temperature of the concrete having a minimum dimension greater than 300 mm shall be between 10 and 20 degrees C. Heating of the mixing water or aggregates will be required to regulate the concrete-placing temperatures. Materials entering the mixer shall be free from ice, snow, or frozen lumps. Salt, chemicals, or other materials shall not be mixed with the concrete to prevent freezing, except that a chemical accelerator may be used.

3.3.5 Hot-Weather Placing

Concrete shall be properly placed and finished with procedures previously submitted in accordance with paragraph SUBMITTALS. The concrete-placing temperature shall not exceed 30 degrees C when measured in accordance with ASTM C 1064. Cooling of the mixing water and aggregates, or both, may be required to obtain an adequate placing temperature. A retarder meeting the requirements of paragraph WATER-REDUCING OR RETARDING ADMIXTURES may be used to facilitate placing and finishing. Steel forms and reinforcement shall be cooled prior to concrete placement when steel temperatures are greater than 50 degrees C. Conveying and placing equipment shall be cooled if necessary to maintain proper concrete-placing temperature.

3.3.6 Consolidation

Immediately after placement, each layer of concrete, including flowing concrete, shall be consolidated by internal vibrating equipment. Vibrators shall not be used to transport concrete within the forms. Hand spading may be required, if necessary, with internal vibrating along formed surfaces permanently exposed to view. Form or surface vibrators shall not be used unless specifically approved. The vibrator shall be inserted vertically at uniform spacing over the entire area of placement. The distance between insertions shall be approximately 1-1/2 times the radius of action of the vibrator. The vibrator shall penetrate rapidly to the bottom of the layer and at least 150 mm into the preceding unhardened layer if such exists. It shall be held stationary until the concrete is consolidated and then withdrawn slowly.

3.3.7 Placing Concrete in Ogee Section

The unformed portion of the ogee section shall be finished by placing concrete slightly above grade and striking off to grade by accurate screeding. Screeding may be accomplished by semimechanical devices or by a mechanical screed that consolidates and screed the surface in one operation. Ribs embedded in the fresh concrete as guides for screeds will not be permitted.

3.4 FINISHING

The ambient temperature of spaces adjacent to surfaces being finished shall be not less than 5 degrees C. In hot weather when the rate of evaporation of surface moisture, as determined by use of Figure 2.1.5 of ACI 305R, may reasonably be expected to exceed 1.0 kilogram per square meter per hour. Provisions for windbreaks, shading, fog spraying, or wet covering with a light-colored material shall be made in advance of placement, and such protective measures shall be taken as quickly as finishing operations will allow. In addition to the above provisions the Contractor may elect to use a pre-cure finishing aid on any horizontal surface. The finishing aid shall be applied at the manufacturers recommended rate immediately after screeding. The finishing aid shall be reapplied immediately after each subsequent finishing operation until the concrete is ready for the installation of the final curing method. All unformed surfaces that are not to be covered by additional concrete or backfill shall have a float finish, unless a trowel finish is specified, and shall be true to the elevation shown on the drawings. Surfaces to receive additional concrete or backfill shall be brought to the elevation shown on the drawings and left true and regular. Exterior surfaces shall be sloped for drainage unless otherwise shown in the drawing or as directed. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. Grate tampers or jitterbugs shall not be used.

3.4.1 Unformed Surfaces

3.4.1.1 Float Finish

Surfaces shall be screeded and darbied or bullfloated to bring the surface to the required finish level with no coarse aggregate visible. No water, cement, or mortar shall be added to the surface during the finishing operation. The concrete, while still green but sufficiently hardened to bear a man’s weight without deep imprint, shall be floated to a true and even plane. Floating may be performed by use of suitable hand floats or power-driven equipment. Hand floats shall be made of magnesium or aluminum.

3.4.1.2 Trowel Finish

A trowel finish shall be applied to the top of channel walls and as indicated on the drawings. Concrete surfaces shall be finished with a float finish, and after surface moisture has disappeared, the surface shall be troweled to a smooth, even, dense finish free from blemishes including trowel marks.

3.4.2 Formed Surfaces

Unless another finish is specified, surfaces shall be left with the texture imparted by the forms except that defective surfaces shall be repaired as described in paragraph FORMED SURFACE REPAIR. Uniform color of the concrete shall be maintained by use of only one mixture without changes in

materials or proportions for any structure or portion of structure that is exposed to view. The form panels used to produce the finish shall be orderly in arrangement. Forms shall not be reused if there is any evidence of surface wear or defects that would impair the quality of the surface.

3.4.3 Formed Surface Repair

After removal of forms, all ridges, lips, and bulges on surfaces permanently exposed shall be removed. All repairs shall be completed within 48 hours after form removal.

3.4.3.1 Classes A & B Finishes

Surfaces listed in Section 03101 FORMWORK FOR CONCRETE and as shown to have classes A and B finishes shall have surface defects repaired as follows: defective areas, voids, and honeycombs smaller than 10 000 square millimeters in area and less than 13 mm deep and bug holes exceeding 13 mm in diameter shall be chipped and filled with dry-packed mortar. Holes left by removal of tie rods shall be reamed and filled with dry-packed mortar as specified in paragraph MATERIAL AND PROCEDURE FOR REPAIRS. Defective and unsound concrete areas larger than described shall be defined by 13 mm deep dovetailed saw cuts in a rectangular pattern with lines parallel to the formwork, the defective concrete removed by chipping, and the void repaired with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of paragraph EPOXY RESIN, a latex bonding agent meeting the requirements of paragraph LATEX BONDING COMPOUND, or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with paragraph MATERIAL AND PROCEDURE FOR REPAIRS.

3.4.3.2 Class D Finish

Surfaces listed in Section 03101 FORMWORK FOR CONCRETE and as shown to have class D finish shall have surface defects repaired as follows: defective areas, voids, and honeycombs greater than 30 000 square millimeters in area or more than 50 mm deep shall be defined by 13 mm deep dovetailed saw cuts in a rectangular pattern, the defective concrete removed by chipping and the void repaired with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of paragraph EPOXY RESIN, a latex bonding agent meeting the requirements of paragraph LATEX BONDING COMPOUND, or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with paragraph MATERIAL AND PROCEDURE FOR REPAIRS.

3.4.3.3 Material and Procedure for Repairs

The cement used in the dry-packed mortar or replacement concrete shall be a blend of the cement used for production of project concrete and white portland cement properly proportioned so that the final color of the mortar or concrete will match adjacent concrete. Trial batches shall be used to determine the proportions required to match colors. Dry-packed mortar shall consist of one part cement to two and one-half parts fine aggregate. The fine aggregate shall be that used for production of project concrete. The mortar shall be remixed over a period of at least 30 minutes without addition of water until it obtains the stiffest consistency that will permit placing. Mortar shall be thoroughly compacted into the prepared void by tamping, rodding, ramming, etc. and struck off to match adjacent concrete. Replacement concrete shall be produced using project materials and shall be proportioned by the Contracting Officer. It shall be

thoroughly compacted into the prepared void by internal vibration, tamping, rodding, ramming, etc. and shall be struck off and finished to match adjacent concrete. Forms shall be used to confine the concrete. If an expanding agent is used in the repair concrete, the repair shall be thoroughly confined on all sides including the top surface. Metal tools shall not be used to finish permanently exposed surfaces. The repaired areas shall be cured for 7 days. The temperature of the in situ concrete, adjacent air, and replacement mortar or concrete shall be above 5 degrees C during placement, finishing, and curing. Other methods and materials for repair may be used only when approved in writing by the Contracting Officer. Repairs of the so called "plaster-type" will not be permitted.

3.5 CURING AND PROTECTION

3.5.1 Duration

All concrete shall be cured by an approved method for a period of 7 days. Immediately after placement, concrete shall be protected from premature drying, extremes in temperatures, rapid temperature change, and mechanical damage. All materials and equipment needed for adequate curing and protection shall be available and at the placement site prior to the start of concrete placement. Concrete shall be protected from the damaging effects of rain for 12 hours and from flowing water for 14 days (7 days with Type III cement). No fire or excessive heat including welding shall be permitted near or in direct contact with concrete or concrete embedments at any time.

3.5.2 Moist Curing

Moist-cured concrete shall be maintained continuously, not periodically, wet for the entire curing period. If water or curing materials stain or discolor concrete surfaces that are to be permanently exposed, they shall be cleaned as required in paragraph APPEARANCE. Where wooden form sheathing is left in place during curing, the sheathing shall be kept wet at all times. Horizontal surfaces may be moist cured by ponding, by covering with a minimum uniform thickness of 50 mm of continuously saturated sand, or by covering with saturated nonstaining burlap or cotton mats. Horizontal construction joints may be allowed to dry for 12 hours immediately prior to the placing of the following lift.

3.5.3 Membrane-Forming Curing Compound

Concrete may be cured with an approved curing compound in lieu of moist curing except that membrane curing will not be permitted on any surface to which other concrete is to be bonded or on any surface containing protruding steel reinforcement. All surfaces shall be cured with pigmented-type curing compound conforming to paragraph CURING MATERIALS subparagraph Membrane-Forming Curing Compound.

3.5.3.1 Application

The curing compound shall be applied to formed surfaces immediately after the forms are removed and prior to any patching or other surface treatment except the cleaning of loose sand, mortar, and debris from the surface. The surfaces shall be thoroughly moistened with water, and the curing compound applied as soon as free water disappears. The curing compound shall be applied to unformed surfaces as soon as free water has disappeared and bleeding has stopped. The curing compound shall be applied in a two-coat continuous operation by approved motorized power-spraying

equipment operating at a minimum pressure of 500 kPa, at a uniform coverage of not more than 5 square meters per liter for each coat, and the second coat shall be applied perpendicular to the first coat. Concrete surfaces that have been subjected to rainfall within 3 hours after curing compound has been applied shall be resprayed by the method and at the coverage specified. All concrete surfaces on which the curing compound has been applied shall be adequately protected for the duration of the entire curing period from pedestrian and vehicular traffic and from any other cause that will disrupt the continuity of the curing membrane.

3.5.4 Evaporation Retardant

Any horizontal concrete surface may be cured using sheet material. All surfaces shall be thoroughly wetted and be completely covered with waterproof paper or polyethylene-coated burlap having the burlap thoroughly water-saturated before placing. Covering shall be laid with light-colored side up. Covering shall be lapped not less than 300 mm and securely weighted down or shall be lapped not less than 100 mm and taped to form a continuous cover with completely closed joints. The sheet shall be weighted to prevent displacement so that it remains in contact with the concrete during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.

3.5.5 Cold-Weather Curing and Protection

When the daily outdoor low temperature is less than 0 degrees C, the temperature of the concrete shall be maintained above 5 degrees C for the first 7 days after placing. In addition, during the period of protection removal, the air temperature adjacent to the concrete surfaces shall be controlled so that concrete near the surface will not be subjected to a temperature differential of more than 15 degrees C as determined by observation of ambient and concrete temperatures indicated by suitable temperatures measuring devices furnished by the Government as required and installed adjacent to the concrete surface and 50 mm inside the surface of the concrete. The installation of the thermometers shall be made by the Contractor at such locations as may be directed. Curing compounds shall not be used on concrete surfaces that are maintained at curing temperature by use of free steam.

3.6 SETTING OF BEAMS ON CONCRETE STRUCTURES

3.6.1 General

After being plumbed and properly positioned, beams and similar structural members shall be provided with full bearing with non-shrink grout. Concrete surfaces shall be rough, clean, and free of oil, grease, and laitance, and they shall be damp. Metal surfaces shall be clean and free of oil, grease, and rust.

3.6.2 Nonshrink Grout Application

Non-shrink grout shall conform to the requirements of paragraph NON-SHRINK GROUT. Water content shall be the minimum that will provide a flowable mixture and fill the space to be grouted without segregation, bleeding, or reduction of strength.

3.6.3 Mixing and Placing of Non-shrink Grout

Mixing and placing shall be in accordance with the material manufacturer's instructions and as specified. Ingredients shall be thoroughly dry-mixed before adding water. After adding water, the batch shall be mixed for 3 minutes. Batches shall be of size to allow continuous placement of freshly mixed grout. Grout not used within 30 minutes after mixing shall be discarded. The space between the top of the concrete and the beam shall be filled solid with the grout. Forms shall be of wood or other equally suitable material for retaining the grout and shall be removed after the grout has set. Temperature of the grout and of surfaces receiving the grout shall be maintained at 20 to 30 degrees C until after setting.

3.6.4 Curing

Grout shall be cured in conformance with paragraph CURING AND PROTECTION.

3.7 TESTS AND INSPECTIONS

Tests and inspections shall conform to the following requirements.

3.7.1 General

The Contractor shall perform the inspections and tests described below, and, based upon the results of these inspections and tests, he shall take the action required and submit reports as required. When, in the opinion of the Contracting Officer, the concreting operation is out of control, concrete placement shall cease. The laboratory performing the tests shall conform with ASTM C 1077. The individuals who sample and test concrete or the constituents of concrete as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I.

3.7.2 Testing and Inspection Requirements

3.7.2.1 Fine Aggregate

a. Grading - At least once during each shift when the concrete is being delivered, there shall be one sieve analysis and fineness modulus determination in accordance with ASTM C 136 and COE CRD-C 104 for the fine aggregate or for each size range of fine aggregate if it is batched in more than one size or classification. The location at which samples are taken may be selected by the Contractor as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits. Results of tests shall be reported in writing.

b. Corrective Action for Fine Aggregate Grading - When the amount passing on any sieve is outside the specification limits, the fine aggregate shall be immediately resampled and retested. If there is another failure on any sieve, the fact shall immediately be reported to the Contracting Officer.

c. Moisture Content Testing - When in the opinion of the Contracting Officer the electric moisture meter is not operating satisfactorily, there shall be at least four tests for moisture content in accordance with ASTM C 566 during each 8-hour period of mixing plant operation. The times for the tests shall be selected randomly within the 8-hour period. An additional test shall be made whenever the slump is shown

to be out of control or excessive variation in workability is reported by the placing foreman. When the electric moisture meter is operating satisfactorily, at least two direct measurements of moisture content shall be made per week to check the calibration of the meter.

d. Moisture Content Corrective Action - Whenever the moisture content of the fine aggregate changes by 0.5 percent or more, the scale settings for the fine-aggregate batcher and water batcher shall be adjusted (directly or by means of a moisture compensation device) if necessary to maintain the specified slump.

3.7.2.2 Coarse Aggregate

a. Grading - At least once during each shift in which the concrete is being delivered, there shall be a sieve analysis in accordance with ASTM C 136 for each size of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. However, the Contractor shall be responsible for delivering the aggregate to the mixer within specification limits. A test record of samples of aggregate taken at the same locations shall show the results of the current test as well as the average results of the five most recent tests including the current test. The Contractor may adopt limits for control which are coarser than the specification limits for samples taken at locations other than as delivered to the mixer to allow for degradation during handling. Results of tests shall be reported in writing.

b. Corrective Action for Grading - When the amount passing any sieve is outside the specification limits, the coarse aggregate shall be immediately resampled and retested. If the second sample fails on any sieve, that fact shall be reported to the Contracting Officer. Where two consecutive averages of five tests are outside specification limits, the operation shall be considered out of control and shall be reported to the Contracting Officer. Concreting shall be stopped and immediate steps shall be taken to correct the grading.

c. Coarse Aggregate Moisture Content - A test for moisture content of each size group of coarse aggregate in accordance with ASTM C 566 or COE CRD-C 112 shall be made at least once per shift. When two consecutive readings for smallest size coarse aggregate differ by more than 1.0 percent, frequency of testing shall be increased to that specified above for fine aggregate, until the difference falls below 1.0 percent. These results shall be used to adjust the added water in the control of the batch plant.

d. Coarse Aggregate Moisture Corrective Action - Whenever the moisture content of any size of coarse aggregate changes by 0.5 percent or more, the scale setting for the coarse aggregate batcher and the water batcher shall be adjusted if necessary to maintain the specified slump.

e. Deleterious Substances - When, in the opinion of the Contracting Officer, a problem exists in connection with deleterious substances in fine or coarse aggregates, tests shall be made in accordance with ASTM C 33 at a frequency not less than one per week. Results of tests shall be reported in writing.

f. Corrective Action for Deleterious Substances - When the results for a deleterious substance is outside the specification limits, the aggregate shall be immediately resampled and retested. If the second

sample fails, that fact shall be reported to the Contracting Officer. Where material finer than the 0.075 mm sieve for coarse aggregate exceeds the specification limit, immediate steps, such as washing or other corrective actions, shall be taken to correct the grading.

3.7.2.3 Scales

a. Weighing Accuracy - The accuracy of the scales shall be checked by test weights prior to start of concrete operations and at least once every month for conformance with the applicable requirements of paragraph BATCHING EQUIPMENT. Such tests shall also be made as directed whenever there are variations in properties of the fresh concrete that could result from batching errors. Results of tests shall be reported in writing.

b. Batching and Recording Accuracy - Once a week the accuracy of each batching and recording device shall be checked during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. The Contractor shall confirm that the calibration devices described in paragraph BATCH PLANT for checking the accuracy of dispensed admixtures are operating properly. Results of tests shall be reported in writing.

c. Scales Corrective Action - When either the weighing accuracy or batching accuracy does not comply with specification requirements, the plant shall not be operated until necessary adjustments or repairs have been made. Discrepancies in recording accuracy’s shall be corrected immediately.

3.7.2.4 Batch-Plant Control

The measurement of all constituent materials including cementitious materials, each size of aggregate, water, and admixtures shall be continuously controlled. The aggregate weights and amount of added water shall be adjusted as necessary to compensate for free moisture in the aggregates. The amount of air-entraining agent shall be adjusted to control air content within specified limits. A report shall be prepared indicating type and source of cement used, type and source of pozzolan used, amount and source of admixtures used, aggregate source, the required aggregate and water weights per cubic meter amount of water as free moisture in each size of aggregate, and the batch aggregate and water weights per cubic meter for each class of concrete batched during plant operation. The report shall be submitted to the Contracting Officer.

3.7.2.5 Concrete Mixture

a. Air Content Testing - At least two tests for air content shall be made on randomly selected batches of each separate concrete mixture produced during each 8-hour period of concrete production. Additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government quality assurance representative. Tests shall be made in accordance with ASTM C 231. For concrete having a nominal maximum aggregate size of 25 or 37 mm, the average of each set of two tests shall be plotted on a control chart on which the average is set at 5.5 percent and the upper and lower control limits at 7 and 4 percent respectively. For concrete having a nominal maximum aggregate size of 19 mm, the average shall be set at 6.0 percent and the upper and lower control limits at 7.0 and 5.0 percent, respectively. The control charts shall be submitted to the Contracting

Officer.

b. Air Content Corrective Action - Whenever points on the control chart for percent air reach either warning limit, an adjustment shall immediately be made in the amount of air-entraining admixture batched. As soon as is practical after each adjustment, another test shall be made to verify the result of the adjustment. Whenever a point on the control chart range reaches the warning limit, the admixture dispenser shall be recalibrated to ensure that it is operating accurately and with good reproducibility. Whenever a point on either control chart reaches an action limit line, the air content shall be considered out of control and the concreting operation shall immediately be halted until the air content is under control. Additional air content tests shall be made when concreting is restarted. All this shall be at no extra cost to the Government.

c. Slump Testing - At least two slump tests shall be made on randomly selected batches in accordance with ASTM C 143 for each separate concrete mixture produced during each 8-hour or less period of concrete production each day. Also, additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government’s quality assurance representative. The average of each set of two tests shall be plotted on a control chart on which the upper and lower limits are set 38 mm above and below the mid-range value. The range shall be plotted on a control chart on which the upper control limit is 75 mm. The control chart shall be submitted to the Contracting Officer.

d. Slump Corrective Action - Whenever points on the control chart for slump reach the upper warning limit, an adjustment shall be immediately made in the batch weights of water and fine aggregate. The adjustments are to be made so that the total water content does not exceed that amount allowed by the maximum W/C specified, based upon aggregates which are in a saturated surface-dry condition. When a single slump reaches the upper or lower action limit, no further concrete shall be delivered to the placing site until proper adjustments have been made. Immediately after each adjustment, another test shall be made to verify the correctness of the adjustment. Whenever two consecutive slump tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range at or above the upper action limit, the concreting operation shall immediately be halted and the Contractor shall take appropriate steps to bring the slump under control. Also, additional slump tests shall be made as directed. All this shall be at no additional cost to the Government.

e. Batch Tickets - The manufacturer of the concrete shall furnish to the Government’s quality assurance representative with each batch of concrete, before unloading at the site, a delivery ticket prepared in accordance with the requirements of ASTM C 94.

f. Compressive-Strength Specimens - At least one set of test specimens shall be made each day on each different concrete mixture placed during the day. Additional sets of test cylinders shall be made, as directed by the Contracting Officer, when the mixture proportions are changed or when low strengths have been detected. A random sampling plan shall be developed by the Contractor and approved by the Contracting Officer prior to the start of construction. The plan shall assure that sampling is done in a completely random and unbiased manner. A set of test specimens for concrete with a 28-day specified strength per

paragraph DESIGN REQUIREMENTS shall consist of four cylinders, two to be tested at 7 days and two at 28 days. A set of test specimens for concrete with a 90-day strength per specified paragraph DESIGN REQUIREMENTS shall consist of six cylinders, two tested at 7 days, two at 28 days, and two at 90 days. Test specimens shall be molded and cured in accordance with ASTM C 31 and tested in accordance with ASTM C 39. All compressive-strength tests shall be reported immediately to the Contracting Officer. Quality control charts shall be kept for individual strength tests, moving average for strength, and moving average for range for each mixture. The charts shall be similar to those found in ACI 214.

g. Temperature - The temperature of the concrete specimen shall be measured in accordance with ASTM C 1064. The temperature shall be reported along with the compressive strength data.

3.7.2.6 Inspection Before Placing

Foundation or construction joints, forms, and embedded items shall be inspected for quality by the Contractor in sufficient time prior to each concrete placement to certify to the Contracting Officer that they are ready to receive concrete. The results of each inspection shall be reported in writing not less than 2 hours prior to placement or by 4:00 P.M. for placements prior to 9:00 A.M. the following day.

3.7.2.7 Placing

a. Placing Inspection - The placing foreman shall supervise all placing operations, shall determine that the correct quality of concrete or grout is placed in each location as directed and shall be responsible for measuring and recording concrete temperatures and ambient temperature hourly during placing operations, weather conditions, time of placement, yardage placed, and method of placement. A report shall be submitted in writing to the Contracting Officer.

b. Placing Corrective Action - The placing foreman shall not permit batching and placing to begin until he has verified that an adequate number of vibrators in working order and with competent operators are available. Placing shall not be continued if any pile of concrete is inadequately consolidated. If any batch of concrete fails to meet the temperature requirements, immediate steps shall be taken to improve temperature controls.

3.7.2.8 Vibrators

a. Vibrator Testing and Use - The frequency and amplitude of each vibrator shall be determined in accordance with COE CRD-C 521 prior to initial use and at least once a month when concrete is being placed. Additional tests shall be made as directed when a vibrator does not appear to be adequately consolidating the concrete. The frequency shall be determined at the same time the vibrator is operating in concrete with the tachometer held against the upper end of the vibrator head while almost submerged and just before the vibrator is withdrawn from the concrete. The amplitude shall be determined with the head vibrating in air. Two measurements shall be taken, one near the tip and another near the upper end of the vibrator head and these results averaged. The make, model, type, and size of the vibrator and frequency and amplitude results shall be reported in writing.

b. Vibrator Corrective Action - Any vibrator not meeting the requirements of paragraph VIBRATORS shall be immediately removed from service and repaired or replaced.

3.7.2.9 Curing

a. Moist-Curing Inspections - At least once per day an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded.

b. Moist-Curing Corrective Action - When a daily inspection report lists an area of inadequate curing, immediate corrective action shall be taken, and the required curing period for such areas shall be extended by one (1) day.

c. Membrane-Curing Inspection - No curing compound shall be applied until the Contractor’s authorized representative has verified that the compound is properly mixed and ready for spraying. At the end of each operation, he shall estimate the quantity of compound used by measurement of the container and the area of concrete surface covered and compute the rate of coverage in square meters per liter. He shall note whether or not coverage is uniform.

d. Membrane-Curing Corrective Action - When the coverage rate of the curing compound is less than that specified or when the coverage is not uniform, the entire surface shall be sprayed again.

e. Sheet-Curing Inspection - At least once each day an inspection shall be made of all areas being cured using material sheets. The condition of the covering and the tightness of the laps and tapes shall be noted and recorded.

f. Sheet-Curing Corrective Action - When a daily inspection report lists any tears, holes, or laps or joints that are not completely closed, the tears and holes shall promptly be repaired or the sheets replaced, the joints closed, and the required curing period for those areas shall be extended by one (1) day.

3.7.2.10 Cold-Weather Protection and Sealed Insulation Curing

At least once per day an inspection shall be made of all areas subject to cold-weather protection. The protection system shall be inspected for holes, tears, unsealed joints, or other deficiencies that could result in damage to the concrete. Special attention shall be taken at edges, corners, and thin sections. Any deficiencies shall be noted, corrected, and reported. During removal of cold-weather protection, measurement of concrete and ambient temperature shall be made at least hourly. A report shall be submitted in writing to the Contracting Officer.

3.7.2.11 Cold-Weather Protection Corrective Action

When a daily inspection report lists any holes, tears, unsealed joints, or other deficiencies, the deficiency shall be corrected immediately and the period of protection extended 1 day.

3.7.2.12 Mixer Uniformity

a. Stationary Mixers - Prior to the start of concrete placing and once every 6 months when concrete is being placed, uniformity of concrete

mixing shall be determined in accordance with ASTM C 94. Whenever adjustments in mixer or increased mixing times are necessary because of failure of any mixer to comply, the mixer shall be retested after adjustment. Results of tests shall be reported in writing.

b. Truck Mixers - Prior to the start of concrete placing and at least once every 6 months when concrete is being placed, uniformity of concrete shall be determined in accordance with ASTM C 94. The truck mixers shall be selected randomly for testing. When satisfactory performance is found in one truck mixer, the performance of mixers of substantially the same design and condition of the blades may be regarded as satisfactory. Results of tests shall be reported in writing.

3.7.2.13 Mixer Uniformity Corrective Action

When a mixer fails to meet mixer uniformity requirements, either the mixer shall be removed from service on the work, the mixing time shall be increased, batching sequence changed, batch size reduced, or adjustments shall be made to the mixer until compliance is achieved.

3.7.3 Reports

All results of tests or inspections conducted shall be reported informally as they are completed and as required. A weekly report shall be prepared for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, reports of pertinent temperatures shall be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all test and inspection records.

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ROLLER-COMPACTED CONCRETE (RCC)

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SECTION 03360

ROLLER-COMPACTED CONCRETE (RCC)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 305R	(1991) Hot Weather Concreting
ACI 347R	(1994) Guide to Formwork for Concrete

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 33	(1993) Concrete Aggregates
ASTM C 117	(1990) Materials Finer Than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	(1989) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(1995a) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 150	(1995) Portland Cement
ASTM C 171	(1992) Sheet Materials for Curing Concrete
ASTM C 172	(1990a) Sampling Freshly Mixed Concrete
ASTM C 174	(1987; R 1991) Measuring Length of Drilled Concrete Cores
ASTM C 494	(1992) Chemical Admixtures for Concrete
ASTM C 566	(1989) Total Moisture Content of Aggregate by Drying
ASTM C 618	(1994a) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C 1040	(1993) Density of Unhardened and Hardened Concrete in Place by Nuclear Methods
ASTM D 1556	(1990) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(1991) Laboratory Compaction

	Characteristics of Soil Using Modified Effort (2,700 kN-m/cu.m.)
ASTM D 3017	(1991) Water Content of Soil and Rock in Place By Nuclear Method (Shallow Depth)
ASTM D 4318	(1993) Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4791	(1995) Flat or Elongated Particles in Coarse Aggregate

CORPS OF ENGINEERS (COE)

COE CRD-C 53	(1991a) Consistency of No-Slump Concrete Using the Modified Vebe Apparatus
COE CRD-C 55	(1991) Within-Batch Uniformity of Freshly Mixed Concrete
COE CRD-C 100	(1975) Method of Sampling Concrete Aggregate and Aggregate Sources, and Selection of Material for Testing
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete

FEDERAL SPECIFICATIONS (FS)

FS CCC-C-467	(Rev C) Cloth, Burlap, Jute or Kenaf

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(1994) NIST Handbook 44: Specifications, Tolerances, and other Technical Requirements for Weighing and Measuring Devices

NATIONAL READY-MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(1990) Concrete Plant Standards

STATE OF NEVADA, DEPARTMENT OF TRANSPORTATION, MATERIALS TESTING DIVISON (NDOT)

NDOT T230C	(Rev C) Method of Test for Determining the Percent of Fractured Faces

1.2 PRECONSTRUCTION TESTING AND MIXTURE-PROPORTIONING STUDIES

1.2.1 RCC Aggregate Sampling and Testing

The aggregate sources listed in Section 03301 paragraph CONCRETE AGGREGATE SOURCES have been tested and at the time testing was performed were capable of producing materials of a quality required for this project. Samples from any source selected, whether listed or not listed, consisting of not less than 70 kilograms of each size of coarse aggregate and 35 kilograms of fine aggregate, and taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100 shall be delivered to a local materials

testing laboratory selected by the Government within 15 days after Notice to Proceed. Sampling, shipment, and testing of samples shall be at the Contractor's expense. Sixty (60) days will be required to complete evaluation of the aggregates. All quality assurance testing will be performed by the Government in accordance with the applicable COE CRD-C or ASTM test methods. Tests to which aggregate may be subjected are specific gravity, absorption, soft particles, L.A. abrasion, and any test necessary to demonstrate that the aggregate is of a quality that is at least equivalent to those sources listed herein and meeting the requirements of ASTM C33. The Government test data and other information on aggregate quality of those sources listed in Section 03301 paragraph CONCRETE AGGREGATE SOURCES are included in the Design Memorandum and are available for review in the district office. Quality assurance testing of aggregates by the Government does not relieve the Contractor of quality control requirements.

1.2.2 Cementitious Materials and Admixtures

At least 60 days in advance of submitting samples for mixture proportioning studies, the Contractor shall notify the Contracting Officer of the source, brand name, type, and quantity of all materials (other than aggregates) to be used in the manufacture and curing of the concrete.

1.2.3 Materials for RCC Mixture-Proportioning Studies

At least 60 days in advance of the time when placing of concrete is expected to begin, samples of representative materials proposed for this project and meeting all the requirements of this specification shall be delivered to the laboratory listed below by the Contractor at his expense.

US Army Engineer Waterways Experiment Station
Structures Laboratory, Concrete Division
3909 Halls Ferry Road
Vicksburg, MS 39180

Samples of aggregates shall be taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100, accompanied by test reports indicating conformance with grading and quality requirements specified. Samples of materials other than aggregates shall be representative of those proposed for the project and shall be submitted accompanied by manufacturer's test reports indicating compliance with applicable specified requirements. Quantities of materials required shall be as follows:

MATERIAL	QUANTITY
Aggregate	2,000 kgs
Cement	300 kgs
Pozzolan	200 kgs
Washed Concrete Sand	300 kgs

Mixture-proportioning studies will be made by the Government at its expense.

1.3 TESTING DURING CONSTRUCTION BY THE GOVERNMENT

1.3.1 General

The Government will sample and test cementitious materials, admixtures, aggregates, and concrete during construction as considered appropriate to determine compliance with the specifications. The Contractor shall provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with COE CRD-C 100. Consistency of the RCC will be determined by the Government using the modified Vebe apparatus in accordance with paragraph CONSISTENCY OF RCC. Compression test specimens of RCC will be made and tested by the Government. Density of the compacted RCC will be checked by the Government as considered appropriate.

1.3.2 Aggregates Sampling and Testing

Testing performed by the Government will not relieve the Contractor of his responsibility for testing under paragraph CONTRACTOR QUALITY CONTROL. During construction, aggregates will be sampled for acceptance testing as delivered to the mixer to determine compliance with specification provisions. The Contractor shall provide necessary facilities and labor for the ready procurement of representative samples under Government supervision. The Government will test such samples at its expense using the specified COE CRD-C and ASTM methods.

1.3.3 Cementitious Materials

Cement or pozzolan will be sampled at the mill, shipping point, or site of the work by the Government. A list of prequalified cement sources and prequalified pozzolan sources is available from the Commander and Director, U.S. Army Engineer Waterways Experiment Station (CEWES-SC-MP), 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199. If tests prove that a material which has been delivered is unsatisfactory, it shall be promptly removed from the site of the work. Cementitious materials that have not been used within 6 months after being tested will be retested by the Government at the expense of the Contractor when directed by the Contracting Officer.

1.3.4 Prequalified Cement Sources

Cement shall be delivered and used directly from a mill of a producer designated as a prequalified source for the type of cement being used. Samples of cement for quality-assurance testing will be taken at the project site or cement-producing plant by the Contracting Officer for testing at the expense of the Government. A copy of the mill tests from the cement manufacturer shall be furnished for each lot.

1.3.5 Prequalified Pozzolan Sources

Pozzolan shall be delivered and used directly from a producer designated as a prequalified source. Samples of pozzolan for check testing will be taken at the project site by the Contracting Officer for testing at the expense of the Government. A copy of the test results from the pozzolan manufacturer shall be furnished for each lot.

1.3.6 Nonprequalified Cement Sources

Cement, if not from a prequalified source, will be sampled and tested by or under the supervision of the Government and at its expense. No cement shall be used until notice has been given by the Contracting Officer that test results are satisfactory. In the event of failure, the cement may be resampled and tested at the request of the Contractor and at the

Contractor's expense. The fill gate or gates of the sampled bin will be sealed and kept sealed until shipment from the bin has been completed. Sealing of the fill gate or gates and of conveyances used in shipment will be done by or under the supervision of the Government. Conveyances will not be accepted at the site of the work unless received with all seals intact. If tested cement is rehandled at transfer points, the extra cost of inspection will be at the Contractor's expense. The cost of testing cement excess to project requirements will also be at the Contractor's expense and will be deducted from payments due the Contractor at a rate of $1.50 per ton of cement.

1.3.7 Nonprequalified Pozzolan Sources

Pozzolan, if not from a prequalified source, will be sampled at the source or at the site of the work and will be stored in sealed bins pending completion of acceptance tests. Pozzolan may be resampled at the site when determined necessary. All sampling and testing will be performed by and at the expense of the Government. Release for shipment and approval for use will be based on compliance with 7-day lime-pozzolan strength requirements and other physical, chemical, and uniformity requirements for which tests can be completed by the time the 7-day lime-pozzolan strength test is completed. Release for shipment and approval for use on this basis will be contingent on continuing compliance with the other requirements of the specifications. If test results of a bin fail, the contents may be resampled and tested at the Contractor's expense. The Government will supervise or perform the unsealing and resealing of bins and shipping conveyances. If tested pozzolan is rehandled at transfer points, the extra cost of inspection will be at the Contractor's expense. The cost of testing excess pozzolan in excess of project requirements will be at the Contractor's expense at a rate of $2.50 per ton. The amount will be deducted from payment to the Contractor.

1.4 CONSTRUCTION TOLERANCES

1.4.1 General

Except as supplemented or modified below, tolerances shall be as required in SECTION 03301.

a. The thickness of compacted lifts of RCC shall be within plus or minus 50 mm of that specified.

b. The elevation of the surfaces of RCC lifts upon which subsequent RCC or conventional concrete is placed shall not vary more than 150 mm from the design elevation, except that the elevation of the top three lifts of the dam shall be within 60 mm of that shown.

c. Tolerances for exposed surfaces of spillway ogee concrete and any other conventional concrete that interfaces with the RCC shall be in accordance with SECTION 03301.

1.5 SUBMITTALS

Government approval is required for all submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01300 SUBMITTAL PROCEDURES:

SD-01 Data

Batch Plant; GA.

Details and data on the concrete plant shall be submitted prior to plant assembly for review by the Contracting Officer for conformance with the requirements of paragraph BATCH PLANT. Final acceptance of any piece of plant is subject to satisfactory performance during operations.

Mixers; GA.

The make, type, capacity, and number of the concrete mixers proposed for use shall be submitted, prior to installation, for review by the Contracting Officer for conformance with the requirements of paragraph MIXERS.

Transporting and Conveying Equipment; FIO. Spreading and Remixing Equipment ; FIO. Compaction Equipment; GA.

A listing of the equipment proposed for transporting, handling, depositing, spreading, and compacting the concrete shall be submitted for review by the Contracting Officer before concrete placement begins. The data submitted shall include site drawings or sketches with locations of equipment and placement site.

SD-08 Statements

Aggregate and Concrete Production; GA.

Descriptions and details for all methods and operations proposed for aggregate and concrete operations including daily and weekly production rates, shall be submitted for review and approval for conformance with specifications.

Joint Cleanup and Waste Disposal; FIO.

The method and equipment proposed for joint cleanup and waste disposal shall be submitted for review by the Contracting Officer before concrete placement begins for conformance with paragraph JOINTS.

Curing; GA.

The curing media and methods to be used shall be submitted for review to the Contracting Officer before concrete placement begins for conformance with paragraph CURING AND PROTECTION.

Vertical Facings; FIO.

Details of the Contractors construction methods and equipment shall be submitted for review within 60 days after Notice to Proceed.

1.6 MATERIAL DELIVERY, STORAGE, AND HANDLING

1.6.1 Cementitious Materials

1.6.1.1 Transportation

When bulk cement or pozzolan is not unloaded from primary carriers directly into weather-tight hoppers at the batching plant, transportation from the railhead, mill, or intermediate storage to the batching plant shall be

accomplished in adequately designed weather-tight trucks, conveyors, or other means that will protect the material from exposure to moisture.

1.6.1.2 Storage

Cementitious materials shall be furnished in bulk. Immediately upon receipt at the site of the work, all cementitious materials shall be stored in a dry, weather-tight, and properly ventilated structure. All storage facilities shall permit easy access for inspection and identification. Sufficient materials shall be in storage for at least two operating days to sustain continuous operation of the mixing plant while the RCC is being placed. In order that cement may not become unduly aged after delivery, the Contractor shall use any cement that has been stored at the site for 60 days or more before using cement of lesser age.

1.6.2 Aggregate Storage

Fine aggregate and each size of coarse aggregate shall be stored in separate size groups, in free-draining stockpiles, adjacent to the batch plant and in such a manner as to prevent the intermingling of size groups or the inclusion of foreign materials in the aggregate. Aggregate shall remain in free-draining storage for at least 24 hours immediately prior to use. Sufficient fine and coarse aggregate shall be maintained at the site at all times to permit continuous uninterrupted RCC placement.

PART 2 PRODUCTS

2.1 CEMENTITIOUS MATERIALS

2.1.1 Portland Cement

Portland cement shall conform to ASTM C 150, Type V, low alkali.

2.1.2 Pozzolan

Pozzolan shall conform to ASTM C 618, Class F, with loss on ignition limited to 6 percent.

2.1.3 Temperature of Cementitious Materials

The temperature of the cementitious materials as delivered to the site shall not exceed 65 degrees C.

2.2 ADMIXTURES

All chemical admixtures furnished as liquids shall be in a solution of suitable viscosity and dilution for field use as determined by the Contracting Officer.

2.2.1 Water-Reducing Admixture (WRA)

A WRA shall meet the requirements of ASTM C 494, Type B or D. The admixture may be added to the concrete mixture only when its use is approved or directed and after mixture proportioning studies.

2.3 CURING MATERIALS

Burlap shall conform to FS CCC-C-467

2.4 WATER

Water for washing aggregates and for mixing and curing concrete shall be free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances and shall comply with COE CRD-C 400.

2.5 AGGREGATES

2.5.1 Source of Materials

Borrow materials for production of RCC aggregates may be obtained from the required excavation or from off-site sources. The contractor shall make all arrangements, and secure all necessary permits for the procurement, furnishing and transporting aggregates from off-site sources.

2.5.2 Particle Shape

The shape of the particles of the fine aggregate and of the coarse aggregate shall be generally spherical or cubical. The quantity of flat and elongated particles at a length-to-width or width-to-thickness ratio greater than 3 in the separated size groups of coarse aggregate, as defined and determined by ASTM D 4791, shall not exceed 25 percent in any size group.

2.5.3 Deleterious Substances

The maximum plasticity index for RCC aggregate materials shall be limited to 3 when determined in accordance with ASTM D 4318.

2.5.4 Resistance to Abrasion

Coarse aggregate, used in production of RCC, shall not show more than 45 percent loss after 500 revolutions when tested in accordance with ASTM C 131.

2.5.5 Fractured Faces

Coarse aggregate, used in production of RCC, will have a minimum 50 percent fractured faces when tested in accordance with NDOT T230C.

2.5.6 Aggregate Gradation

Aggregate samples will be prepared for RCC mix design studies. The Government will use the specified gradations for use in preparation of mixture proportioning studies.

2.5.6.1 RCC Gradation

The aggregate base to be used for RCC construction, when tested in accordance with ASTM C 117 and ASTM C 136, shall conform to the gradation indicated below:

Standard Sieve Size	Percent Passing by Weight
50 mm	100
19 mm	90 - 100
4.75 mm	35 - 65
1.18 mm	15 - 40
0.075 mm	2 - 10

2.6 RCC MIXTURE PROPORTIONING

2.6.1 Composition

RCC mixture will be proportioned by the Contracting Officer. RCC shall be composed of cementitious materials, water, aggregates, and possibly admixtures. The cementitious material shall be portland cement, or portland cement in combination with pozzolan. An admixture when approved or directed will be a water-reducing/retarding admixture. Other admixtures shall not be used unless demonstrated by the Contractor to be beneficial, approved in writing, and used in the mixture proportioning studies.

2.6.2 Proportions

The proportions of all materials entering the RCC, as determined from the mixture proportioning studies, will be furnished to the Contractor by the Contracting Officer. The mixture proportions shall be changed by the Contractor during construction as directed by the Contracting Officer's representative. Adjustments will be made to the batch weights including cement, pozzolan, and water to maintain the necessary consistency to prevent segregation within the RCC and allow full compaction as determined. Frequent changes to the batch weights shall be considered usual and can be expected to occur frequently during the course of each day's placement depending on such variables as humidity, wind velocity, temperature, and cloud cover. Such changes will be as directed. The Contractor will be responsible for adjusting the aggregate weights to compensate for changes in aggregate moisture contents.

2.6.3 Cementitious Material Content

The total cementitious material content of the RCC will range from an approximate minimum of 150 to an approximate maximum of 250 kilograms per cubic meter, expressed as equivalent portland cement content (by absolute volume). If the contractor elects to use a pozzolan, it shall be furnished and will be proportioned to be between fifteen and thirty percent by absolute volume of the total cementitious material.

2.6.4 Consistency of RCC

The Contracting Officer will determine at the placement site on a continuing basis the proper consistency necessary for adequate hauling, spreading, and compacting and will direct all necessary changes to achieve the proper RCC consistency. Changes will be directed based on visual examination of the RCC during the spreading and compaction process and on the Vebe time when it varies outside the range considered ideal for compaction, as determined by the Government using the modified Vebe apparatus, in accordance with COE CRD-C 53.

2.7 BEDDING MORTAR

2.7.1 General

Bedding mortar is to be used for achieving bond between RCC lifts as indicated in paragraph JOINTS. No surfaces to receive a bedding mortar shall be covered with RCC until the prepared surface has been approved and that acceptance has been recorded on an approved checkout form. In no case will the bedding mortar be allowed to dry from the sun and wind.

2.7.2 Bedding Mortar Mix

The bedding mortar mix design will be developed by the government and will conform to the following general requirements. Aggregate for bedding mortar shall conform to the requirements of ASTM C 33, for washed concrete sand.

Parameter	
Slump	200-250 mm
Cement Content	250-300 kg/m^3
Minimum Compressive Strength	15 Mpa (28 days)

2.7.3 Installation

Bedding mortar shall be spread over the lift joint and other horizontal contact surfaces before placement of the next RCC lift. The bedding mortar shall be spread so that the maximum thickness of bedding does not exceed 12 mm, and the average thickness determined by dividing the volume used by the area covered is approximately 6 mm. Bedding mortar placements shall be controlled to prevent bleeding of the mortar through the RCC. The bedding mortar shall be covered with the designated RCC mix within 10 minutes after placement of the bedding mortar. Consolidation of the bedding mortar will not be required. Serrated rakes creating small windrows of mortar or other approved devices shall be used for mortar application.

PART 3 EXECUTION

3.1 STOCKPILING OF MATERIAL

3.1.1 General

Whether obtained from the required excavation or off-site commercial sources, aggregates shall not be transported directly to the mixing plant. The aggregates shall be stockpiled on firm ground drained and leveled, free of debris, trash, organic materials, and other objectionable or deleterious material. Stockpiles shall be constructed in layers not exceeding 1 meter in thickness. Ramps formed for the construction of stockpiles shall be made of the same material as that being stockpiled, and will be considered a part of the stockpile. Aggregates taken from the stockpile for RCC production shall be removed from the stockpile in such a manner that material from several layers of the stockpile are combined in each sample and the gradation of the aggregate obtained is representative of that used in the mix design tests.

3.2 EQUIPMENT

3.2.1 Capacity

The concrete plant, conveying, placing, compaction, and cleanup systems shall have a capacity of at least 100 cubic meters per hour.

3.2.2 Concrete Plant

The concrete plant shall be a batch or a continuous mixing plant.

3.2.2.1 Location

The concrete plant shall be located on project site, subject to the approval of the Contracting Officer.

3.2.2.2 Bins and Silos

Separate bins, compartments, or silos shall be provided for each size or classification of aggregate and for each of the cementitious materials. The compartments shall be of ample size and so constructed that the various materials will be maintained separately under all working conditions. All compartments containing bulk cement or pozzolan shall be separated from each other by a free-draining air space. The cement and pozzolan bins shall be equipped with filters which allow air passage but preclude the venting of cement or pozzolan into the atmosphere. All filling ports shall be clearly marked with a permanent sign stating the contents.

3.2.2.3 Batch Plant

The batch plant requirements should meet the following requirements.

a. Batchers - Aggregate shall be weighed in separate weigh batchers with individual scales or may be batched cumulatively. Bulk cement and other cementitious materials shall each be weighed on a separate scale in a separate weigh batcher. Water shall be measured by weight or by volume. It shall not be weighed or measured cumulatively with another ingredient. Ice shall be measured separately by weight. Admixtures shall be batched separately and shall be batched by weight or by volume in accordance with the manufacturers recommendations.

b. Water Batcher - A suitable water-measuring and batching device shall be provided that will be capable of measuring and batching the mixing water within the specified tolerances for each batch. The mechanism for delivering water to the mixers shall be free from leakage when the valves are closed. The filling and discharge valves for the water batcher shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. When a water meter is used, a suitable strainer shall be provided ahead of the metering device.

c. Admixture Dispensers - A separate batcher or dispenser shall be provided for the admixture. The plant shall be equipped with the necessary calibration devices that will permit convenient checking of the accuracy of the dispensed volume of the particular admixture. The batching or dispensing devices shall be capable of repetitively controlling the batching of the admixtures to the accuracy specified. Piping for liquid admixtures shall be free from leaks and properly valved to prevent backflow or siphoning. The dispensing system shall include a device or devices that shall detect and indicate the presence or absence of the admixture or provide a convenient means of visually observing the admixture in the process of being batched or discharged. The system shall be capable of ready adjustment to permit varying the quantity of admixture to be batched. The dispenser shall be interlocked with the batching and discharge operations so that each admixture is added separately to the batch in solution in a separate portion of the mixing water in a manner to ensure uniform distribution of the admixtures throughout the batch during the required mixing period. Storage and handling of admixtures shall be in accordance with the manufacturer’s recommendations.

d. Moisture Control - The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the masses of the materials being batched.

e. Scales - Adequate facilities shall be provided for the accurate measurement and control of each of the materials entering each batch of concrete. The weighing equipment and controls shall conform to the applicable requirements of NIST HB 44, except that the accuracy shall be within 0.2 percent of the scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Each weighing unit shall include a visible indicator that shall indicate the scale load at all stages of the weighing operation and shall show the scale in balance at zero load. The weighing equipment shall be arranged so that the concrete plant operator can conveniently observe the indicators.

f. Operation and Accuracy - The weighing operation of each material shall conform to requirements of NRMCA CPMB 100. The weigh batchers shall be so constructed and arranged that the sequence and timing of batcher discharge gates can be controlled to produce a ribboning and mixing of the aggregates, water, admixtures, and cementitious materials as the materials pass through the charging hopper into the mixer. The plant shall include provisions to facilitate the inspection of all operations at all times. Delivery of materials from the batching equipment shall be within the following limits of accuracy:

MATERIAL	PERCENT OF REQUIRED MASS
Cementitious materials	0 to +2
Water	±2
Each individual aggregate size group	±2
Chemical admixtures	0 to 6

When water or chemical admixtures are measured by volume, they shall meet the same tolerance percent as stated in the chart.

g. Interlocks - Batchers and mixers shall be interlocked so that:

(1) The charging device of each batcher cannot be actuated until all scales have returned to zero balance within plus or minus 0.2 percent of the scale capacity and each volumetric device has reset to start or has signaled empty.

(2) The charging device of each batcher cannot be actuated if the discharge device is open.

(3) The discharge device of each batcher cannot be actuated if the charging device is open.

(4) The discharge device of each batcher cannot be actuated until the indicated material is within the allowable tolerances.

(5) Admixtures are batched automatically and separately with the water.

(6) The mixers cannot be discharged until the required mixing time has elapsed.

h. Recorder - An accurate recorder or recorders shall be provided and shall conform to the following detailed requirements:

(1) The recorder shall produce a graphical or digital record on a single visible chart or tape of the weight or volume of each material in the batchers at the conclusion of the batching cycle. The record shall be produced prior to delivery of the materials to the mixer. After the batchers have been discharged, the recorder shall show the return to empty condition.

(2) A graphical recording or digital printout unit shall be completely housed in a single cabinet that shall be capable of being locked.

(3) The chart or tape shall be so marked that each batch may be permanently identified and so that variations in batch weights of each type of batch can be readily observed. The chart or tape shall be easily interpreted in increments not exceeding 0.5 percent of each batch weight.

(4) The chart or tape shall show time of day at intervals of not more than 15 minutes.

(5) The recorder chart or tape shall become the property of the Government.

(6) The recorder shall be placed in a position convenient for observation by the concrete plant operator and the Government inspector.

(7) The recorded weights or volumes when compared to the weights or volumes actually batched shall be accurate within plus or minus 2 percent.

i. Batch Counters - The plant shall include devices for automatically counting the total number of batches of all concrete batched and the number of batches of each preset mixture.

j. Batch Plant Trial Operation - Not less than 7 days prior to commencement of placing the test section, a test of the batching and mixing plant shall be made in the presence of a representative of the Contracting Officer to check operational adequacy. The number of full-scale concrete batches required to be produced in trial runs shall be as directed, will not exceed 20, and shall be proportioned as directed by the Contracting Officer. All concrete produced in these tests shall be wasted or used for purposes other than inclusion in structures covered by this specification. All deficiencies found in plant operation shall be corrected to the satisfaction of the Contracting Officer prior to the start of concrete placing operations. No separate payment will be made to the Contractor for labor or materials required by provisions of this paragraph. Mixer uniformity testing, in accordance with paragraph CONTRACTOR QUALITY CONTROL, will be performed by the government near the end of this trial operation period. The Contractor shall notify the Contracting Officer of the trial operation not less than 7 days prior to the start of the trial

operation.

k. Protection - The weighing, indicating, recording, and control equipment shall be protected against exposure to dust, moisture, and vibration so that there is no interference with proper operation of the equipment.

3.2.2.4 Continuous Mixing Plant

A continuous mixing plant(s) shall be capable of producing RCC of the same quality and uniformity as would be produced in a conventional batch plant and shall be capable of producing a uniform continuous product (at both maximum and minimum production rates) that is mixed so that complete intermingling of all ingredients occurs without balling, segregation, and wet or dry portions.

a. Operation and Accuracy - An electronic control system shall be provided. The control system shall have the capability of changing mixtures instantaneously, producing any of the mixtures at a variable rate, and tracking a mixture change to a hopper or a conveyor system. The control panel shall display for each ingredient the designed formula values and the instantaneous percentage values and shall record the instantaneous values at a preset time interval or on demand with a multiple copy printer/recorder. The recorder shall note formula changes and shall print total quantities of each ingredient and total amounts produced on command. There shall be weighing devices (belt scale or other) for continuous weighing of individual ingredients and total ingredients. The plant control shall not require manual devices to adjust the material flow. The plant shall be capable of total manual control operation for a single product at a limited production for short-time durations in the event of loss of electronic control. The electronic control system shall incorporate modular replaceable components to reduce down time in the event of control system malfunction. An inventory shall be maintained of such replaceable components. The fine aggregate shall have a device that monitors its moisture content immediately prior to dispensing into the mixing plant dispensing system. The accuracy of the plant dispensing systems shall be within the following limits:

Cementitious Materials	0 to +2 percent
Water	(2 percent
Each individual aggregate size group	.(2 percent
Admixtures	0 to +6 percent

The continuous feeders for each of the ingredients shall be calibrated as per the manufacturer’s specifications. Devices and tools shall be maintained at the plant location to check the feeder’s calibration at the Contracting Officer’s request. A technician shall be provided that is skilled in calibration of the feed devices and the maintenance and repair of the plant control system. The technician shall be available within 30 minutes notice during all scheduled plant operations. The technician could be one or more of the Contractor’s personnel.

b. Cement, Pozzolan, and Aggregate Feed - Cement, pozzolan, and aggregates shall be uniformly, continuously, and simultaneously fed (at the proper ratios and quantity for the mixture required) into the mixer by belt, auger, vane feeder, or other acceptable method. The feed bins

or silos for each ingredient shall be kept sufficiently full and shall be of sufficient size to ensure a uniform flow at a constant rate for a specific mixture. The feed bins shall have a low-level indicator that both warns the operator and can shut the plant down if insufficient material is available for a uniform and continuous flow.

c. Water and Admixture Dispensers - The liquid-dispensing devices shall be capable of metering and dispensing within the specified requirements. The liquid valves shall be free from leakage in the closed position. The dispensers shall have attachments and/or be installed in such a manner that will permit convenient checking of their accuracy. Plumbing shall be leak-free and properly valved to prevent backflow and siphoning. The dispenser shall be interlocked with the electronic plant control and shall warn the operator and shut down the plant if insufficient liquid is available. Separate nozzles for each liquid shall be properly located at the mixer to assure uniform distribution of each liquid to the materials entering the mixer.

d. Continuous Mixer(s) - The continuous mixer(s) shall have proper introduction of ingredients as specified by the manufacturer and shall not be charged in excess of the manufacturer’s recommended capacity. Mixer(s) shall be capable of combining the materials into a uniform homogeneous mixture and of discharging this mixture without segregation. The mixer(s) shall operate at the blade speed designated by the manufacturer and shall be capable of changing retention time of the ingredients in the mixer. This should be accomplished by manually resetting the mixer(s) blade angles. Mixing time (ingredient retention time in the mixer) shall be predicated upon the uniformity, homogeneity, and consistency of the resultant mixture. Samples for uniformity testing shall be taken at 2-minute intervals and tested as per COE CRD-C 55. The mixer(s) shall be maintained in satisfactory operating condition and mixer blades shall be kept free of hardened concrete. Should mixer(s) at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired. Suitable facilities shall be provided for obtaining representative samples of concrete for testing. All necessary platforms, shelters, tools, labor, and equipment shall be provided for obtaining samples.

e. Segregation - A means shall be used to reduce and minimize segregation and waste which would otherwise result from the continuous stream of concrete being fed into the batch haul devices (concrete buckets, dump trucks, etc.). The equipment shall retain the concrete between tracks or other means of transport to prevent the need for stopping the mixer. These devices could include, but not be limited to, small-volume conveyor discharge hopper with a large gate that is automatically opened on a timed interval, thereby dumping a series of small batches into larger batch hoppers, trucks, or truck beds.

f. Trial operation - Not less than 7 days prior to commencement of concrete placing, a test of the plant shall be made in the presence of a representative of the Contracting Officer to check operational adequacy. The number of cubic meters required to be produced in trial runs shall be as directed, but will not exceed 100 cubic meters and shall be proportioned as directed by the Contracting Officer. All concrete produced in these tests shall be wasted or used for purposes other than inclusion in structures covered by this specification. All deficiencies found in plant operation shall be corrected to the satisfaction of the Contracting Officer prior to the start of concrete placing operations. Mixer uniformity tests by the Government will be

performed near the end of this trial period. No separate payment will be made to the Contractor for labor or materials required by provisions of this paragraph. The Contractor shall notify the Contracting Officer of the trial operation not less than 7 days prior to the start of the trial operation.

g. Protection - The weighing, indicating, recording, and control equipment shall be protected against exposure to dust, moisture, and vibration so that there is no interference with proper operation of the equipment.

h. Discharge Hopper - The pugmill mixer shall be equipped with a discharge hopper having a capacity of at least 20 metric ton. The hopper shall be equipped with dump gates to assure rapid and complete discharge without segregation.

3.2.3 Mixers

Mixers shall be stationary mixers or pugmill mixers. Mixers may be batch or continuous mixing. Each mixer shall combine the materials into a uniform mixture and discharge this mixture without segregation. Mixers shall not be charged in excess of the capacity recommended by the manufacturer on the nameplate. Excessive overmixing requiring additions of water will not be permitted. The mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free of hardened concrete. Mixer blades or paddles shall be replaced when worn down more than 10 percent of their depth when compared with the manufacturer’s dimension for new blades. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired or replaced.

3.2.3.1 Pugmill Mixers

A batch or continuous mixing twin-shaft pugmill mixer shall be capable of producing RCC of the same quality and uniformity as would be produced in a conventional plant that meets all the requirements of these specification. All pugmill mixers shall meet the requirements of paragraph CONTINUOUS MIXING PLANT.

3.2.3.2 Mixer Uniformity Requirements

All mixers shall be tested by the Government in accordance with this paragraph and in accordance with COE CRD-C 55. When regular testing is performed, the RCC shall meet the limits of any three of the four applicable uniformity requirements. When abbreviated testing is performed, the concrete shall meet only those requirements listed for abbreviated testing. The initial mixer evaluation test shall be a regular test and shall be performed prior to the start of concrete placement. The concrete proportions used for the evaluation shall contain the largest size aggregate on the project and shall be as directed by the Contracting Officer. Regular testing shall consist of performing all tests on three batches of concrete. The range for regular testing shall be the average of the ranges of the three batches. Abbreviated testing shall consist of performing the required tests on a single batch of concrete. The range for abbreviated testing shall be the range for one batch. Mixer evaluations shall be performed by the Government. The Contractor shall provide labor and equipment as directed by the Contracting Officer to assist the Government in performing the tests.

PARAMETER	REGULAR TESTS ALLOWABLE MAXIMUM RANGE FOR AVERAGE OF 3 BATCHES	ABBREVIATED TESTS ALLOWABLE MAXIMUM RANGE FOR 1 BATCH
Coarse aggregate, percent	6.0	6.0
Compressive strength at 7 days	10.0	10.0
Water content, percent	1.5	1.5
Consistency, modified Vebe, second	7.0	--

A regular test will be performed before concrete production begins and when the Contractor requests a reduced mixing time. An abbreviated test shall be performed every 3 months when concrete is being placed. If a mixer fails the abbreviated test, a regular test will be performed. Cost of testing when the Contractor requests a reduced mixing time will be paid by the Contractor.

3.2.4 Sampling Facilities

3.2.4.1 Sampling Concrete

The Contractor shall provide suitable facilities and labor for obtaining representative samples of concrete in accordance with ASTM C 172 for Contractor quality control and Government quality assurance testing.

3.2.4.2 Sampling Aggregates

Suitable facilities shall be provided for readily obtaining representative samples of aggregates for test purposes immediately prior to the material entering the mixer.

3.2.5 Transporting and Conveying Equipment

The transporting and conveying equipment shall conform to the following requirements.

The concrete mixtures (RCC, bedding mortar, concrete, and any other concrete that will interface with the RCC) shall be conveyed from the plant mixer(s) to placement as rapidly and as continuously as practical by methods which limit segregation, contamination, and surface drying. The RCC shall be conveyed from the mixing plant to the structure by means of main-line conveyor, end-dump truck, or a combination thereof.

3.2.6 Spreading and Remixing Equipment

The spreading and remixing equipment shall conform to the following requirements:

The primary spreading procedure shall be accomplished by track dozer. The dozers shall be equipped with well maintained grousers. The equipment shall be maintained in good operating condition. The equipment shall not leak or drip oil, grease, or other visible contaminants onto the RCC surface. All equipment used for spreading and remixing that leaves the surface of the structure for maintenance or repairs or, for any other reason, must be cleaned of all contaminants by an approved method before returning to the structure surface. Under no conditions shall a dozer or other tracked vehicle be

operated on other than fresh uncompacted RCC except to facilitate startup operations for each lift and by approved procedures.

3.2.7 Compaction Equipment

The compaction equipment shall conform to the following requirements.

3.2.7.1 Primary Rollers

Self-propelled vibratory rollers shall be used for primary rolling and shall be double-drum. They shall transmit a dynamic impact to the surface through a smooth steel drum by means of revolving weights, eccentric shafts, or other equivalent methods. The compactor shall have a minimum gross mass of 9000 kg and shall produce a minimum dynamic force of 60 000 N/m of drum width. The operating frequency shall be variable in the approximate range of 1,700 to 3,000 cycles per minute. The amplitude shall be adjustable between 0.4 and 1.0 mm. The roller shall be capable of full compaction in both forward and reverse directions. The roller shall be operated at speeds not exceeding 0.7 m/s. Within the range of the operating capability of the equipment, the Contracting Officer may direct or approve variations to the frequency, amplitude, and speed of operation which result in the specified density at the fastest production rate.

3.2.7.2 Small Vibratory Rollers

Small vibratory rollers shall be used to compact the RCC where the larger vibratory rollers specified above cannot maneuver. The rollers shall compact the RCC to the required density and shall be so demonstrated during construction of the test section. Small vibratory rollers cannot compact the RCC to the same density and thickness as the primary rollers; therefore, when small rollers are used, total lift thickness of the RCC layer or lift shall be reduced to not over 150 mm uncompacted thickness to permit adequate compaction. Rollers shall have independent speed and vibration controls and shall be capable of a wide range of speed adjustments.

3.2.7.3 Tampers (Rammers)

The tampers shall compact the RCC to the required density and shall be so demonstrated during construction of the test section. Tampers cannot compact the RCC to the same density and thickness as the primary rollers; therefore, when tampers are used, thickness of each RCC layer that is to be compacted shall be reduced to not more than 150 mm uncompacted thickness to assure adequate compaction.

3.2.8 Nuclear Density Gauge

Tests to determine the density of both the uncompacted and compacted RCC shall be made by the Contractor using a two-probe nuclear density gauge supplied by the Contractor. The nuclear density gauge shall meet the applicable requirements of ASTM C 1040. The gauge shall be capable of taking readings along a horizontal path between the probes at 50-mm increments from 50 mm from the surface to 600 mm below the surface. The gauge and operator shall be made available to the Government until completion of all RCC production at no additional cost. The Contractor shall obtain all permits and certifications for the equipment and the operators.

3.2.9 Calibration

Nuclear gauges shall have been factory calibrated within 6 months of RCC placement. The Contractor shall construct, at no additional costs to the Government, three conventional concrete test blocks using RCC aggregate materials, and with dimensions 300 mm larger than the gauge dimensions. The concrete shall be formulated to have densities of approximately 2100, 2300, and 2600 kg/cu m using the RCC materials and so far as possible, similar relative proportions. Completed blocks shall be weighed and measured to determine unit weight. Gauge calibration constants shall be adjusted for performance on these blocks at least 7 days prior to the evaluation of test strips. The Contractor shall remedy any inconsistencies in gauge performance prior to the start of RCC placement. After the start of RCC placement, gauges shall be field recalibrated against cast blocks every 24 hours.

3.3 SUBGRADE PREPARATION

Previously constructed underlying material shall be conditioned as specified in Section 02250 FILLS AND SUBGRADE PREPARATION. The existing subgrade, other than specified fills, shall be scarified, conditioned to optimum moisture content, and compacted to at least 90 percent of maximum density in accordance with ASTM D 1557 for a depth of least 300 mm. In all cases prior to placing RCC, deficiencies in the underlying material shall be corrected, and the surface shall be cleaned and moistened, as directed. The surface of the underlying material will be approved by the Contracting Officer.

3.4 PREPARATION FOR PLACING

3.4.1 Placing Schedule

Before starting RCC production, a detailed schedule shall be submitted indicating intended daily and weekly production rates that, when followed, will meet the beginning and ending specified RCC production dates. After initiation of RCC production, the Contractor’s schedule shall be updated and adjusted on a weekly basis for the duration of the RCC placement. If it becomes apparent for any reason that the Contractor is not pursuing a schedule that will meet the specified RCC production dates, actions necessary to increase the production rate shall be taken so that production is once again on schedule.

3.4.2 RCC Orientation Session

Prior to or in conjunction with the construction of the RCC test section, supervisors and all other Contractor personnel which are expected to participate in the production of RCC for this job (including laborers, equipment operators, foremen, and QC and inspection staff) shall participate in a 2-hour orientation session organized by the Contracting Officer. The Contractor shall provide a facility suitable for slide and videotape presentation. The intent is to orient all individuals on the goals of the RCC placement process, provide clarification of specification requirements if requested, and be provided orientation as to what constitutes good construction practices. Additional orientation sessions will also be made available to, and shall be attended by, all new Contractor personnel who are subsequently hired and that will be involved with the production of the RCC.

3.4.3 Aggregate Production Schedule

Aggregate production and initial stockpiling shall begin and shall be producing acceptable material by not later than 60 days in advance of the time when placement of the RCC test section is expected to begin. At least 50 percent of all RCC aggregates for each size group necessary for the completed RCC construction shall be manufactured and stockpiled prior to start of placement of RCC.

3.4.4 RCC Test Section

Prior to placement of any RCC, the Contractor shall construct a test section at the job site. The purpose of the test section is to demonstrate the suitability of the Contractor's equipment, methods, and personnel. The test section shall consist of not less than two adjacent paving lanes, at least 20 meters in length. The section shall be constructed to at least the depth of 6 lifts. The lane width shall be 3.5 meters. The test section shall contain at least one fresh longitudinal construction joint, one cold transverse joint, one longitudinal cold construction joint which has stood overnight before completion, and one surface to be treated with bedding mortar. The site of the test section shall be approved by the Contracting Officer. After evaluation and assessment of the test section by the Contracting Officer, the Contractor shall dispose of the test section in an approved manner. Under no circumstances shall the test section be incorporated into or become a part of the permanent RCC structure. The test section shall demonstrate sustained plant production rates, and batching, mixing, transporting, spreading, compaction procedures, curing and preparation of construction joints. It shall also demonstrate the vertical face construction method along one side (formed), the sloped face construction method along another side (unformed), procedures for foundation preparation, procedures for placement of bedding mortar, rolling pattern, joint preparation, rolling method for both fresh and cold construction joints, start-up and finishing procedures, testing methods, and plant operations. Variable amplitudes of the roller shall be used as approved in different areas to identify the optimum amplitude. Rolling pattern of the vibratory roller may be varied as approved to determine the best pattern. Variations in mixture proportions other than water shall be made if directed. The test section shall be placed in portions as directed by the Government. The Contractor shall vary the water content, as necessary, to arrive at the appropriate content, subject to the approval of the Contracting Officer's Representative. The mixing plant shall be operated and calibrated prior to placing the test section. The Contractor shall use the same equipment, materials, and construction techniques on the test section as will be used in all subsequent work. The Contractor shall not begin RCC operations for the main structure until testing and evaluations by the Government have been completed, and it has been demonstrated to the satisfaction of the Contracting Officer that all specification requirements were met. If the Contractor does not meet requirements as specified, an additional test section or sections shall be constructed at no additional cost to the Government. Test sections unacceptable to the Contracting Officer shall be removed at the Contractor's expense. The Contractor shall provide twelve (12) 152.4 mm diameter cores to the Government from points selected in the test section by the Government 5 days after completion of the test section. The date of the test section construction shall be provided at least 7 days in advance.

3.4.5 Weather

If unusual adverse weather, such as heavy rain, severe cold, high winds, heavy snow, etc., occurs or is forecast to occur during placement, the placement operation shall be suspended until conditions improve.

3.4.5.1 Placing During Cold Weather

Placement shall be discontinued when the air temperature reaches 5 degrees C and is falling and shall not be resumed until the air temperature reaches 2 degrees C and is rising. No RCC shall be placed on any surface containing frost or frozen material. Provision shall be made to protect the RCC from freezing during the specified curing period. Mixing water and/or aggregates shall be heated, as necessary, to produce RCC having a temperature between 10 degrees C and 30 degrees C as placed. Methods and equipment for heating shall be as approved. The aggregates shall be free of ice, snow, and frozen lumps before entering the mixer. Covering and other means shall be provided for maintaining the RCC at a temperature of at least 10 degrees C for not less than 72 hours after placing and at a temperature above freezing for the remainder of the curing period. RCC damaged by freezing shall be removed and replaced as directed.

3.4.5.2 Placing During Rain

RCC shall not be placed during rainfall of 5 mm/hr or more. During periods of lesser rainfall, placement of RCC may continue if, in the opinion of the Contracting Officer, no damage to the RCC is occurring. Work shall commence only after excess free surface water and contaminated paste or RCC have been removed and the surface has gained sufficient strength (no less than 4 hours after the RCC placement was suspended) to prevent rutting, pumping, intermixing of rainwater with the RCC, or other damage to the RCC. When the RCC surface has been contaminated or damaged in any manner, the RCC surface shall be washed to break up and remove laitance and/or mud-like coatings from the surface. Any undercut coarse aggregate shall be removed. All waste shall be removed and disposed of in an approved manner.

3.4.5.3 Placing During Hot Weather

During periods of hot weather when the maximum daily air temperature is likely to exceed 30 degrees C; or when the combination of ambient conditions will produce evaporation rates of 1.0 kg/sq m/hr or more, when calculated in accordance with Figure 2.1.5 of ACI 305R; the following precautions shall be taken. The maximum period between placing succeeding lifts or lanes shall be 30 minutes. The underlying material shall be sprinkled with water immediately before placing the RCC. The RCC shall be placed at the coolest temperature practicable, and in no case shall the temperature of the RCC when placed exceed 32 degrees C. The aggregates and/or mixing water shall be cooled as necessary. The finished surfaces of the newly laid RCC shall be kept damp by applying a waterfog or mist, not streams of water, with approved spraying equipment until the RCC is covered by the curing medium. When heat or wind is determined excessive by the Contracting Officer, the Contractor shall immediately take such additional measures as necessary to protect the RCC surface. Such measures shall consist of wind screens, more effective fog sprays, and similar measures commencing immediately after placement. If these measures are not effective, placement shall be immediately stopped until satisfactory conditions exist.

3.4.6 Surface Preparation

3.4.6.1 Cleaning

All lift surfaces including any RCC or bedding mortar shall be cleaned prior to placing any additional concrete thereon. After cleaning, bedding

concrete and bedding mortar are to be used specifically for achieving bond between different types of concrete eliminating and preventing segregation or voids along margins or RCC placements. No surfaces to receive bedding mortar shall be covered with RCC until the prepared surfaces have been accepted in writing and that acceptance has been recorded on an approved checkout form. All surfaces upon which RCC, structural concrete or any bedding mortar or bedding mix is placed shall be moist (but contain no visible free water). Prior to placing any concrete adjacent to the RCC and/or the ogee section, the surface shall be clean and free of loose, or unkeyed rock; all mud and silt accumulations; laitance; puddles or ponds of free surface water; coatings; and any other detrimental materials. High-pressure water jetting, and/or wet sandblasting, followed by mild high-volume, low-pressure washing, shall be used on all hardened RCC surface (cold joints) as necessary for the removal of laitance, coatings, stains, or other difficult-to-remove contaminants. High-volume low-pressure water washing and/or water jetting may be used for removal of loose materials.

3.4.6.2 High-Volume Low-Pressure Washing

Washing of loose materials can be accomplished with high-volume low-pressure water washing and/or air water jetting using equipment of similar design to that used in large-scale foundation cleanups. The air-water jets shall have 40-mm nozzles, a water supply of at least 2 L/s, and compressed air at the jet of 550 to 850 kPa. The low-pressure water jets shall have 25-mm nozzles available and a capacity of at least 13 L/s for truck-mounted devices.

3.4.6.3 High-Pressure Water Jet

A stream of water under a pressure of not less than 10.3 MPa for RCC shall be used for cleaning all cold joint surfaces, or surfaces with laitance, mortar coatings, stains, or other difficult-to-remove contaminants. There shall be no undercutting of coarse-size aggregates. Aggregate particles that are undercut shall be removed.

3.4.6.4 Wet Sandblasting

This method may be used when the RCC has reached sufficient strength to prevent undercutting of coarse aggregate particles. Wet sandblasting shall be continued until all accumulated laitance, coatings, stain, or other difficult-to-remove contaminants are removed. Wet sandblasting may be used in lieu of or in combination with the high-pressure water jet.

3.4.6.5 Waste Disposal

Any waste water employed in cutting, washing, and rinsing of concrete surfaces, and any other surface water shall not stain, or affect exposed surfaces of the structure(s) or damage the environment of the project area.

3.5 PLACING

3.5.1 Procedures

Placement of RCC shall be of such depth that when compacted, the surface will conform with cross section, grade, and contour indicated. Each edge of each lane shall be constructed with a vertical or a 15 degrees from vertical configuration, as directed. Mixtures shall be placed in consecutive adjacent strips of such size that the strip can be compacted in

the time specified. If more than 45 minutes shall elapse between placement in adjacent lanes, or subsequent lifts the construction joint shall be considered a "cold joint" and treatment as specified herein for cold joints shall be provided. Not more than 45 minutes shall elapse between placement of lifts. During hot weather, both of these limits will be decreased by the Contracting Officer as specified in paragraph PLACING DURING HOT WEATHER or as otherwise considered appropriate. Each strip placed before a succeeding strip shall be of such length that, where practical, the succeeding strip can be placed without the use of a cold joint. Otherwise, the joint shall be constructed as a cold joint. The length of a strip that is to be followed by another strip shall be approved and shall be decreased or increased as required by air temperatures, wind, and other climatic conditions existing at the time of placement. Placing of mixture shall be as nearly continuous as possible, with an absolute minimum of stops and starts; speed of placing shall be controlled, to permit proper rolling. The timing of placement shall be controlled so that RCC mixtures shall be placed and rolled within the time limit specified in paragraph COMPACTION. Placing shall be discontinued during rain except for light mists which do not cause intermixing of cement and water slurry on the surface. Placing shall be done in a pattern so that curing water from previous placements will not pose a runoff problem on the fresh surface or base course. The contractor shall use care to minimize the production of cold joints.

3.5.2 Bedding Mortar

The bedding mortar shall be applied to the existing surface following any required cleanup. The bedding mortar shall be applied not more than 15 minutes ahead of RCC placement, unless otherwise approved. The bedding mortar shall be used between different RCC placements where cold joints occur, between conventional concrete and RCC, and other locations as directed or as shown in the drawings. The bedding mortar shall have an average thickness after application of between 6 and 12 mm and shall cover 100 percent of the lift area.

3.5.3 Lift Thickness

The total lift thickness after final compaction by the vibratory roller shall not exceed 300 mm.

3.5.4 Depositing, Spreading, and Remixing

After the RCC has been deposited, the RCC shall be spread by dozers into gently sloping layers, approximately 150 mm thick, that will, after final compaction of the several layers by the vibratory roller, result in the specified lift thickness. During the spreading process, the dozer operators shall continuously work the RCC surfaces with the dozer blade and grousers in a manner to remix any RCC that may contain pockets of segregated material and to compact the material. All surfaces of each layer shall receive at least two passes with the grousers. The dozers shall be operating continuously during the spreading process, even if this action results in more than two passes. In no case shall the RCC, or bedding mortar be allowed to dry. Under no conditions shall a dozer or other tracked vehicle be operated on other than fresh uncompacted RCC except at the start of each lift placement to facilitate startup operations, and then only by an approved procedure. No RCC shall be placed on a previous lift which has not met specification. Unacceptable material shall be removed.

3.6 COMPACTION

Compaction shall be accomplished by self-propelled, vibratory, steel-wheeled rollers and rubber-tired rollers. Rolling shall begin within 10 minutes of spreading and, except for fresh joints, rolling shall be completed within 45 minutes of start of mixing, except during hot or dry weather conditions, as described in paragraph Placing During Hot Weather. In hot or dry weather, rolling shall begin within 5 minutes of spreading and, except for joints, rolling shall be completed within 30 minutes of start of mixing. Delays in rolling freshly laid mixture will not be permitted. Rollers shall not be operated in the vibratory mode when not moving. The frequency and amplitude of vibration shall be varied, as needed or directed, within the range specified in paragraph EQUIPMENT. After initial vibratory rolling, preliminary tests and examination of density, grade, smoothness, and surface texture shall be made by the Contractor under the supervision of the Contracting Officer. Before rolling is continued, deficiencies shall be corrected so that the finished surface will conform to requirements for grade, surface texture, and smoothness specified herein. Further smoothness checks shall be as directed by the Contracting Officer. Rolling shall be continued with the vibratory roller in vibratory mode, if necessary, until wet field density of not less than 95 percent of the "Target Density" is attained. Nuclear density testing shall be performed in accordance with paragraph CONTRACTOR QUALITY CONTROL. Surfaces of roller drums and wheels shall be kept clean at all times. Vibratory rolling beyond that specified above will not be permitted.

3.6.1 RCC Compaction

RCC layers shall be compacted to at least 95 percent of the Optimum Compaction Density (OCD). The Optimum Compaction Density (OCD) will be determined during placement of demonstration strips using the supplied mix design and Contractor supplied aggregates, materials, and equipment. Density shall be measured using a nuclear density meter and a sand cone. Nuclear density meter and sand cone tests shall be conducted in accordance with ASTM C 1040 and ASTM D 1556 respectively. Compacted RCC which indicates soft or yielding materials shall be tested immediately with the nuclear meter for moisture and density. If test results confirm that the RCC moisture content exceeds that specified, the soft or yielding area(s) will be removed and replaced by the Contractor at no additional cost to the Government. Upon completion of the OCD demonstration strip(s) the Government shall provide the Contractor with procedural placement requirements and the Contractor shall proceed with RCC production placement.

3.6.1.1 Determination of Optimum Compaction Density (OCD)

The OCD method will be used to determine the requirement for achieving minimum density. All OCD determinations shall be performed by the Contractor in the presence of the Contracting Officer. The OCD will be invalid if material proportions, including water, are outside the designated ranges. OCD demonstration strip compaction will commence no later than 10 minutes after mixing of the RCC.

3.6.1.2 Initial Determination of OCD

The initial OCD value will be determined during placement of RCC demonstration strip(s). The density of the RCC shall be determined for every one (1) or two (2) passes of compaction equipment, concurrently on the same demonstration strip in 2 locations. Compaction shall continue until the change in density decreases significantly. The OCD shall be the

average maximum recorded density. A variation in OCD from the two locations of more than 32 kgs/m^3 shall invalidate the test and require that another test set be performed. The number of roller passes to achieve OCD shall be a guide to the equipment operators of the required compaction necessary to achieve OCD.

3.6.2 Operation of Rollers and Tampers

Speed of rollers shall be slow enough at all times to avoid displacement of the RCC but in no case more than 2.5 km/hr. Displacement of RCC resulting from reversing direction of roller or from any other cause shall be immediately corrected. Alternate passes of the roller shall be varied slightly in length and shall overlap sufficiently to provide full coverage over the surface. Additional rollers shall be furnished if RCC density specified is not attained and/or if placing operations are getting ahead of rolling. In no case shall the Contractor allow placing operations be altered without approval of the Contracting Officer’s Representative. Places inaccessible to large vibratory rollers shall be thoroughly compacted with walk-behind rollers and hand-tampers to the required density, using multiple thin lifts, as necessary. Additional field density tests shall be made for those areas by the Contractor and may also be made by the Government.

3.6.3 Rolling Pattern

Rolling shall commence at the outer edge of the lane abutting either a bulkhead, previously compacted RCC, or a construction joint. On subsequent placement, rolling shall begin at the previously compacted material. If there will be a subsequent lane placed along an edge and the joint will be constructed as a "fresh" joint, the roller shall go no closer to the outer edge until the subsequent lane is placed. If there will be a subsequent lane and the joint will be treated as a "cold" construction joint, or if the edge will be the final edge of the RCC, the outer 450 mm shall be rolled after rolling of the center of the lane. If the edge abuts a previously placed strip, either as a "fresh" joint or as a "cold" joint, the uncompacted joint area shall be rolled after the center of the lane. This joint area shall be given additional passes of the vibratory roller and rubber-tired roller, as necessary, to produce the specified compaction in the joint area. Approved hand-finishing operations shall be used as necessary to produce a tight surface at the joint. The rolling pattern shall be used consistently throughout production.

3.7 JOINTS

Joints shall conform to the details indicated and shall be perpendicular to the finished grade of the RCC. Joints shall be straight and continuous from edge to edge. Construction joints shall be made to ensure continuity in smoothness and grade between old and new sections of RCC, as specified hereinafter. All joints shall have the same texture, full-depth density, and smoothness as specified for other sections. Regardless of age, contact surfaces of previously constructed strips that have become coated with dust, sand, or other objectionable material shall be cleaned by brushing or cut back with approved power saw, as directed.

3.7.1 Lift Joints

The entire RCC shall be placed with sufficient continuity so that it hardens and acts as one monolithic structure without discontinuous joints or potential planes of separation. All lift joints shall be kept clean,

uncontaminated, free from ponded water, and continuously moist until placement of the succeeding RCC. Regular lift-joint treatment and maintenance shall include:

a. Maintaining 100 percent of each compacted lift-joint surface continuously moist,

b. If necessary, removing all loose contaminants or deteriorated RCC by low-pressure washing and/or vacuuming, and

c. Application of a 6 to 12 mm thick bedding mortar over the entire placement surface area immediately before placement of the next lift.

3.7.1.1 Normal Conditions

If the subsequent lift can be placed in less than two hours, the surface must be kept moist. Whenever the contractor’s operations are interrupted such that the subsequent lift cannot be placed within 2-hours the surface shall be scarified to a depth of at least 50-mm with a spike toothed harrow prior to placement of the subsequent lift. The scarified surface shall then be cleaned using a high pressure water spray or other method approved by the Contracting Officer to completely free the surface of all loose material and ponded water prior to the placement of the subsequent lift. During periods of hot weather as defined in Paragraph: Placing During Hot Weather, the time period shall be reduced to 1-hour.

3.7.1.2 Delayed Placement

When placement of the overlying lift does not occur within 4 hours the surface prior to placement shall be treated with a bonding layer. During periods of hot weather as defined in Paragraph: Placing During Hot Weather, the time period shall be reduced to 2-hours.

3.7.2 Longitudinal Construction Joints

Any construction joints in which the edge of the initial strip has exceeded the time requirements given in paragraph PLACING shall be considered "cold joints" and shall be trimmed by sawing the edge of the hardened soil-cement or RCC with a power concrete saw, not earlier than 12 hours age. The sawcut shall be at least 150 mm from the original edge, and more if necessary to produce an acceptable joint. The sawcut shall be full depth of the RCC and shall produce a face within 15 degrees of vertical, free of all loose or uncompacted material. The outer portion shall be removed carefully to prevent any damage to the sawed face. If damage occurs, the edge shall be resawed.

3.7.3 Transverse Construction Joints

When a transverse construction joint is required, the roller shall pass over the end of the freshly placed RCC. In these cases, the previously placed materials shall be cut with a power concrete saw to full depth of the lift, as specified above, and the excess material removed. When necessary, the fresh mixture shall be hand finished at the joints. Additional rolling shall be used to assure that specified full-depth density and surface finish is attained.

3.8 CURING AND PROTECTION

3.8.1 General

Temporarily exposed surfaces of RCC that will be in contact with succeeding layers of RCC shall be kept continuously moist by moist curing or impervious-sheet curing methods described hereinafter until placement of the subsequent layer. Curing of permanently exposed surfaces shall begin immediately after compaction and shall continue for at least 14 days. When wood or metal forms are left in place during curing, the forms shall be kept continuously wet. RCC shall be cured and protected from premature drying, extremes in temperature, rapid temperature change, freezing, mechanical damage and exposure to rain or flowing water. The Contractor shall have all equipment needed for adequate curing and protection on hand and ready to install before actual placement begins. The curing medium and method, or the combination of mediums and methods used, shall be approved by the Contracting Officer. The RCC shall be protected from the damaging effects of rain for 12 hours and flowing water for 14 days.

3.8.2 Moist Curing

RCC will be moist cured by maintaining all surfaces continuously, not periodically, wet for the duration of the entire curing period. Water for curing shall comply with the requirements of paragraph: WATER. If water is used which stains or discolors RCC surfaces which are to be permanently exposed, the surfaces shall be cleaned to the satisfaction of the Contracting Officer. Horizontal surfaces may be cured by covering with a minimum uniform thickness of 150 mm of continuously saturated sand. Temporarily exposed surfaces may not be cured by saturated sand. Horizontal construction joints may be allowed to dry for twelve hours immediately prior to the placing of the following lift.

3.8.3 Truck Applications

Water trucks shall be used, as necessary, to keep surfaces wet at all times until a sprinkler system, wet burlap covering, or final curing method is implemented. The water truck shall be supplemented, as necessary, by mists from hand-held hoses. The truck operator shall be positioned so he is capable of seeing the spray at all times. The spray shall be capable of easy direction, either by attachment to the front of the truck so it can be directed by steering the truck or by other approved means. All spray nozzles both on the trucks and the hand held hoses shall be of a type that produces a true fog spray without any concentrated streams of water. The mist shall not be applied in a channelized or pressurized manner that in any way erodes the surface of the RCC. It shall also be applied at a rate which does not cause ponding at the surface. Trucks shall not be allowed to drop visible oil or other contaminants on the surface. If trucks must leave the surface, the tires shall be washed free of dirt or other foreign material before returning to the surface. Water truck wheel loads shall not exceed 2000 kg and shall be such that no cracking or other damage to the RCC is caused.

3.8.4 Sprinkler System

An approved sprinkler system consisting of pipe lines and rotating or other approved type of sprinklers may be used. Sprinklers shall deliver a fine mist of water and shall not cause any erosion to the surface of the RCC. The sprinkler system shall cover all portions of the RCC surface, and keep the surface wet at all times.

3.8.5 Burlap

Burlap covers shall consist of two or more layers of burlap having a combined weight of 4736 gm per square meter in a dry condition. Burlap shall be either new or shall have been used only for curing RCC or conventional portland cement concrete. Burlap strips shall have a length after shrinkage of at least 300 mm greater than necessary to cover the entire width and edges of the RCC. Mats shall overlap each other at least 150 mm. Mats shall be thoroughly wetted before placing and shall be kept continuously wet and in intimate contact with the surface and edges of the area for the entire specified curing period.

3.8.6 Cure Water Runoff Control

Any water applied to the surface of the RCC or burlap during curing that is in excess of the amount needed to keep the surface of the RCC continuously wet shall be controlled from running onto the base course and causing ponding on the base course or saturation of the base or subbase material.

3.8.7 Protection of RCC

After final rolling of the RCC, no vehicular traffic, except for pneumatic-tired water spray trucks or other curing equipment having wheel loads not exceeding 2000 kg shall be permitted on the RCC until the end of the curing period. No traffic or equipment shall be allowed on the surface that will cause any damage to the surface. Plastic sheeting meeting the requirements of ASTM C 171 shall be provided and kept readily available to cover RCC less than 12 hours old if rainfall occurs.

3.9 FORMED VERTICAL FACINGS FOR RCC SPILLWAY

The vertical faces of the RCC spillway are to be constructed using a form similar to conventional concrete forms as shown and specified in the drawings. The vertical facings system shall be demonstrated on one side of the RCC test section.

3.9.1 Forms for Vertical Facing

Vertical and near-vertical facings shall be as shown in the drawings. The contract drawings are based on designs whereby all vertical and near-vertical faces are constructed at the same time and placement rate of each RCC lift. The design and engineering of the formwork, as well as its construction, shall be the responsibility of the Contractor. The formwork shall be designed for loads, lateral pressure, and allowable stresses in accordance with Chapter 1 of ACI 347R. Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the RCC and shall have sufficient rigidity to maintain specified tolerances. The required sequence of construction operations after all forms and surface preparations have been approved is: place the uncompacted RCC (at the specified lift thickness) at full width against the forms; using dozer action, spread each thin RCC layer abutting against the forms, compact the RCC using the vibratory roller except the step edge shall be compacted with a hand-held tamper or vibrating plate compactor. Extreme care shall be taken to assure all time restrictions are met and to prevent the occurrence of any openwork, honeycombing, or voids at the formed RCC surface. The Contractor’s construction techniques and equipment used including form anchor capability shall be satisfactorily demonstrated during construction of the test section.

3.10 RCC SPILLWAY/PCC OGEE INTERFACE

3.10.1 RCC Spillway Approach and PCC Ogee Section

The ogee section shall be constructed as shown and in accordance with the requirements in SECTION 03301. Prior to placing the PCC ogee above and against the RCC spillway, the RCC surface contact shall be scarified to a depth of at least 50-mm using a spike tooth equipment. The scarified surface shall then be cleaned using a high pressure water spray or other method approved by the Contracting Officer to completely remove all loose material and ponded water. Bedding mortar shall be applied over the scarified RCC surface prior to concrete placement.

3.11 FINISHING SURFACE FOR RCC SPILLWAY WALLS AND CUTOFF SECTION

After compaction to the required lines and grades as shown in the drawings, RCC surfaces shall be reasonably smooth with no trimming allowed. Finishing of the RCC surface shall be conducted at the completion of each day=s production.

3.12 CONTRACTOR QUALITY CONTROL

3.12.1 General

The following tests and inspections shall be the responsibility of the Contractor and shall be performed by an approved commercial testing laboratory or by approved Contractor personnel:

a. Calibration of mixing plant.

b. Sampling, gradation, and quality testing of aggregates during construction.

c. Aggregate moisture tests.

d. Moisture-density testing.

e. Field density and moisture testing.

f. Coring to provide specimens for the Government to determine RCC thickness, including filling the core holes as directed.

g. Inspection during placing.

Based upon the results of these tests, the Contractor shall take the action and submit reports as required below, and any additional tests to ensure that the requirements of these specifications are met. Any test results requested by the Government for review shall be provided to the Government immediately, and all results of every test by the Contractor shall be furnished to the Government on a daily basis, not later than the day after the test or inspection is made. All core drilling shall be performed by skilled personnel experienced in such work. Verification tests of materials, RCC, and finished structural elements, if made by the Government, shall in no way relieve the Contractor from the testing requirements specified herein.

3.12.2 Inspection Details and Frequency of Testing

The following number of tests will be the minimum acceptable for each type of operation:

3.12.2.1 Calibration of Mixing Plant

a. Batch-Mixing Plants: Accuracy of the batching equipment shall be checked for each type of cementitious material and aggregate at the beginning of operations and at least once for every 10 shifts in the presence of the Contracting Officer's representative. Such checks shall also be made whenever there are variations in properties of the fresh RCC which could be the result of batching errors. Standard test weights accurate to plus or minus 0.1 percent shall be provided for checking plant scales.

b. Continuous-Mixing Plants: Accuracy of proportioning of the continuous-mixing plant shall be checked for each cementitious material every day at the beginning of operations and for each aggregate at the beginning of construction and after every 10 shifts. The accuracy of proportioning shall be checked by simultaneously securing timed samples of the cementitious materials and the combined aggregate as they are fed to the mixer and weighing each as appropriate.

c. Mixing Time: Mixing time of the pug mill shall be checked at the direction of the Government. Unless otherwise required, determination of mixing time shall be by weight method using the following formula:

Mixing time in seconds = pug mill dead capacity in kg; pug mill output in kg per second

3.12.2.2 Sampling, Sieve Analysis, and Quality of Aggregate

a. Sampling: Sampling and testing of aggregates during construction shall be performed by an approved commercial testing laboratory using appropriate Corps of Engineers and ASTM test methods.

b. Sieve Analysis: A sieve analysis on the fine and coarse aggregates as delivered to the mixer shall be made by the Contractor at the specified frequency. Before starting work, at least one sample of aggregate shall be tested in accordance with ASTM C 136 and ASTM C 117. The aggregate shall not be used unless results verify that the aggregate complies with the specified gradation and tolerances. After the initial test, a minimum of one analysis shall be performed for each 400 cubic meters or portion thereof of RCC material placed each shift. When deficiencies are found, the rate of testing shall be increased as directed. When two consecutive tests show the aggregate to be deficient in grading, the mixing operation shall be stopped until acceptable material is furnished for delivery to the mixer.

c. Aggregate Quality Tests: During construction, the Contractor shall test for quality the aggregates used for RCC construction. Tests shall consist of Los Angeles abrasion, clay lumps, and specific gravity determination. Tests for quality shall be performed at least once for each 4 000 cubic meters of placed RCC and otherwise when there may be a visual change in the aggregate.

3.12.2.3 Aggregate Moisture Tests

At the beginning of the day and as otherwise directed by the Contracting Officer, the Contractor shall perform moisture content tests on the coarse and fine aggregates in accordance with ASTM C 566.

3.12.2.4 Field Density Testing

a. Calibration Blocks for the Nuclear Density Gauge: Calibration blocks shall be fabricated by the Contractor with RCC materials and proportions representative of those to be used during construction. The blocks shall be used each day before paving begins to calibrate the full-depth readings of the nuclear density gauges used by the Contractor and the Government. The blocks shall be fabricated before the test section construction begins. The blocks size shall be a minimum of 450 mm by 450 mm by the maximum thickness of one lift, plus 25 mm. The blocks shall be compacted to between 98 and 100 percent of the maximum wet density, which will be determined by the Government in accordance with ASTM D 1557. The moisture content of the RCC used to fabricate the blocks may be increased just enough to facilitate compaction of the mixture, as long as the proportions of the dry materials remain constant and the required density is achieved. The blocks shall be measured and weighed to determine the actual density (unit weight) and shall be used to check the calibration of the nuclear density gauge. After drilling a hole in the block to accommodate the nuclear density gauge probe, three full depth nuclear density gauge tests shall be performed in the direct transmission mode and the results averaged. This average nuclear density gauge reading shall be compared with the measured unit weight of the blocks and the difference used as a correction factor for all readings taken that day. All measuring and weighing of the test blocks and all calibration checking of the density gauge shall be performed in the presence of a representative of the Contracting Officer. Calibration checks of the density gauge shall be made at the beginning of construction every day. The calibration block shall be available for use by the Government as needed.

b. Field Density and Moisture Testing: Field density tests shall be performed on the RCC in accordance with ASTM C 1040 as soon as possible, but within 30 minutes, after the completion of vibratory rolling. Only wet density shall be used for evaluation. The test shall be performed using a single probe nuclear density gauge operating in the direct transmission mode so density of the full depth of the RCC can be measured. Each test shall include readings at depths of 75, 150, 225 and 300 mm; however, only the deepest reading shall be used to evaluate the density. Both wet and dry densities shall be reported, and all individual readings shall be reported. The moisture content shall be determined in accordance with ASTM D 3017 at the same depths. The wet field density shall also be reported as a percentage of the "Target Density," maximum laboratory wet density as determined for that lot in accordance with ASTM D 1557. All holes left in the RCC as a result of nuclear density testing by both the Government and the Contractor shall be filled by the Contractor with a cement grout, as directed.

c. Frequency of Field Density and Moisture Testing: At least one field density test shall be performed for each 30 m of paving lane of each layer of RCC and at least one for each 30 m of longitudinal and transverse construction joint. Additional tests shall be made as directed, particularly during start-up and when problems with attaining required density occur.

3.12.2.5 Coring Specimens to Determine Thickness

Cores shall be drilled by the Contractor from points in the RCC within 7 days after placement. A minimum of three cores per days placement will be

taken from locations selected in a random fashion by the Contracting Officer. Cores shall be 150 mm diameter. Additional cores shall be drilled by the Contractor if required as specified in paragraph Thickness. Refilling of core holes shall be performed with portland cement mortar, using materials and procedures directed. Cores shall become the property of the Government and may be tested for strength determination or other properties as considered appropriate.

3.12.2.6 Inspection During Placing

The Contractor's Quality Control organization shall supervise all placing operations and shall be responsible for measuring and recording RCC temperature, ambient temperature, weather conditions, time of placement, yardage placed, and method and location of placement.

a. Cold-Weather Placing: At least once during each shift, an inspection shall be made of all areas subject to cold-weather protection. Deficiencies shall be noted. During removal of protection, the RCC, and ambient temperature shall be measured at least hourly.

b. Hot-Weather Placing and Initial Curing at All Times: When the maximum daily air is likely to exceed 30 degrees C, the Contractor shall take and record the temperature of the RCC mixture at 30-minute intervals during hot-weather placement. The surface of the subgrade shall be inspected to assure that it is sprinkled with water immediately before the RCC is placed and any deficiencies noted. Regardless of ambient temperature, the finished RCC shall be inspected to assure that it is kept damp until the curing medium is applied and any deficiencies noted and immediately brought to the attention of the Contracting Officer's representative. Immediate steps shall be taken to correct any deficiencies.

c. Curing Operation: The curing operation shall be inspected to assure that the surface of the RCC is kept very moist (or wet) continuously until the end of the curing period.

3.12.3 Action Required

3.12.3.1 Mixing Plant

Whenever it is found that either the weighing or the batching accuracy does not comply with specification requirements, the plant shall be shut down until necessary adjustments or repairs have been made. Discrepancies in recording shall be corrected immediately.

3.12.3.2 Aggregate Grading and Quality

a. Grading: When the amount passing any sieve is outside the specification limits or tolerances, the aggregate shall be immediately resampled and retested. If the second sample fails on the same sieve, that fact shall be reported to the Contracting Officer and immediate steps shall be taken to correct the grading.

b. Quality: When the aggregate fails to meet the specification limits for Los Angeles abrasion, clay lumps and friable particles, lightweight pieces, other soft particles, and specific gravity, the Contracting Officer shall be notified immediately and approved corrective action shall be taken.

3.12.3.3 Field Density and Moisture Testing

If any nuclear density gauge reading is below 95 percent, another test shall be performed within a 1.5 to 2.5 m radius of the previous testing location. If this adjacent reading is also below the density requirements, the Contracting Officer shall be notified immediately, and additional vibratory roller passes shall be made across the full lane width between the last testing location that produced an acceptable reading and the placement operations. If additional vibratory roller passes cause the density to decrease or cause the surface texture and appearance to deteriorate in the opinion of the Contracting Officer, the paving operation shall be discontinued until appropriate adjustments are made to the moisture content of the mixture, to placement operations, rolling procedures, or other operations to assure that the specified density and surface requirements can be achieved.

3.12.3.4 Thickness Evaluation

The thickness of the RCC will be determined by the Contractor on the basis of measurements made on cores drilled by the Contractor from locations outlined in paragraph CONTRACTOR QUALITY CONTROL. Measurements of individual cores will be performed in accordance with ASTM C 174. When the measurement of any core indicates that the RCC is deficient in thickness by 12.7 mm or more, additional cores shall be drilled by the Contractor at 8 m intervals, on all sides of the deficient core until the cores indicate that the deficiency in thickness is less than 12.7 mm. When cores indicate a deficiency in thickness of less than 12.7 mm those, areas may be accepted provided the average thickness for the days placement, of the particular material, represented by the core is at least the specified thickness. When cores indicate a deficiency in thickness of 12.7 mm or more, the area represented by that core shall be removed and replaced with RCC of the specified thickness at no additional cost to the Government. If the Contractor believes that the cores and measurement taken are not sufficient to indicate fairly the actual thickness of the RCC, additional cores shall be taken and will be measured provided the Contractor shall bear the extra cost of drilling the cores.

3.12.3.5 Inspection

a. Temperature Protection: The Contracting Officer shall be notified whenever the RCC temperature during the period of protection or protection removal fails to comply with the specifications, and immediate steps shall be taken to correct the situation. Regardless of the ambient temperature, when the temperature of the RCC mixture exceeds 32 degrees C, mixing and placing shall be stopped and the Contracting Officer notified.

b. Curing Operation: The Contracting Officer shall be notified when any RCC surface is allowed to dry before the end of the curing period, and immediate steps shall be taken to correct the situation.

c. Reports: All results of tests conducted at the project site shall be reported daily and shall be delivered to a designated representative of the Contracting Officer. During periods of cold weather protection, reports of pertinent temperatures shall be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failure and the action taken shall be confirmed in writing

in the routine reports. The Contracting Officer has the right to examine all Contractor quality control records at any time.

-- End of Section --